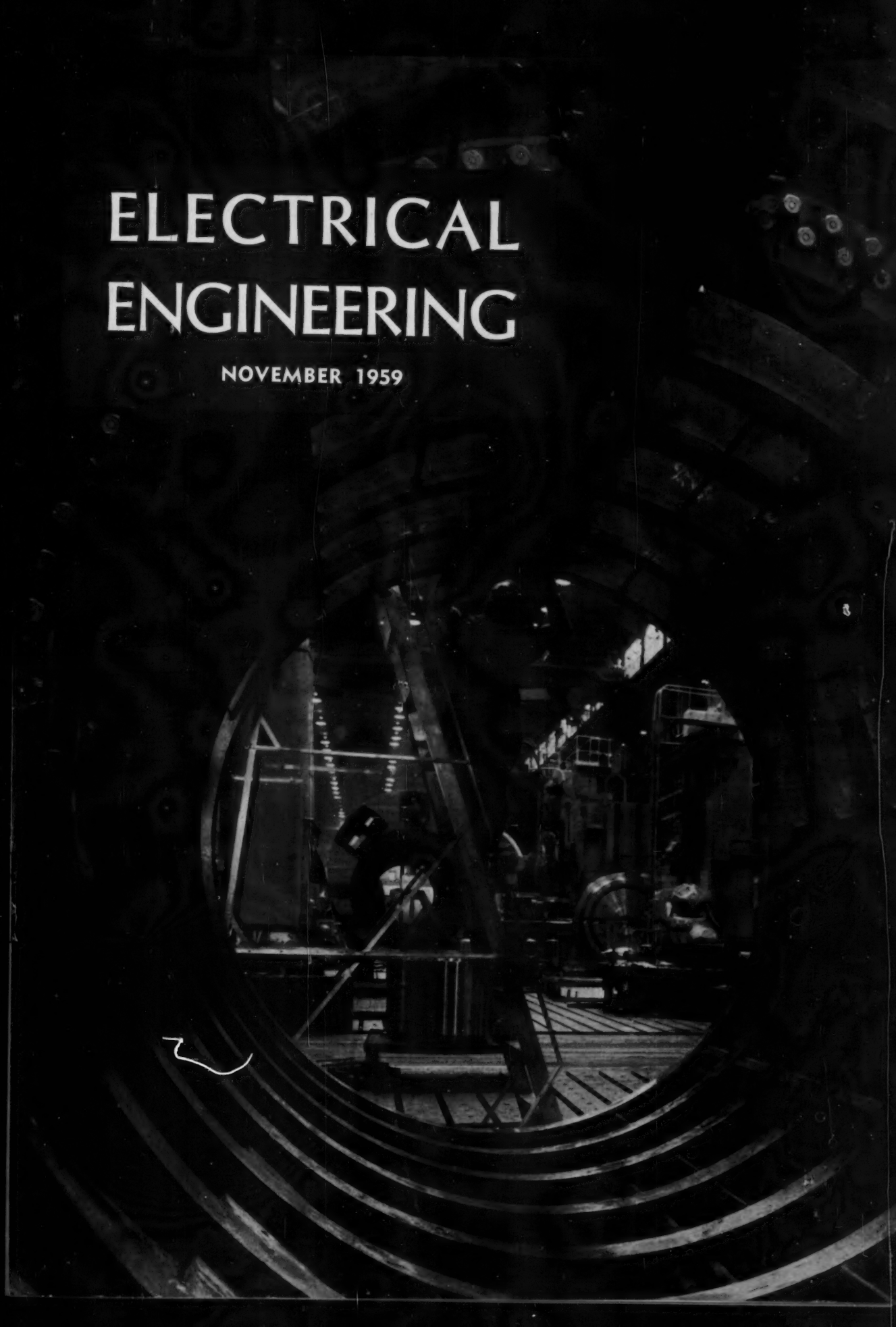
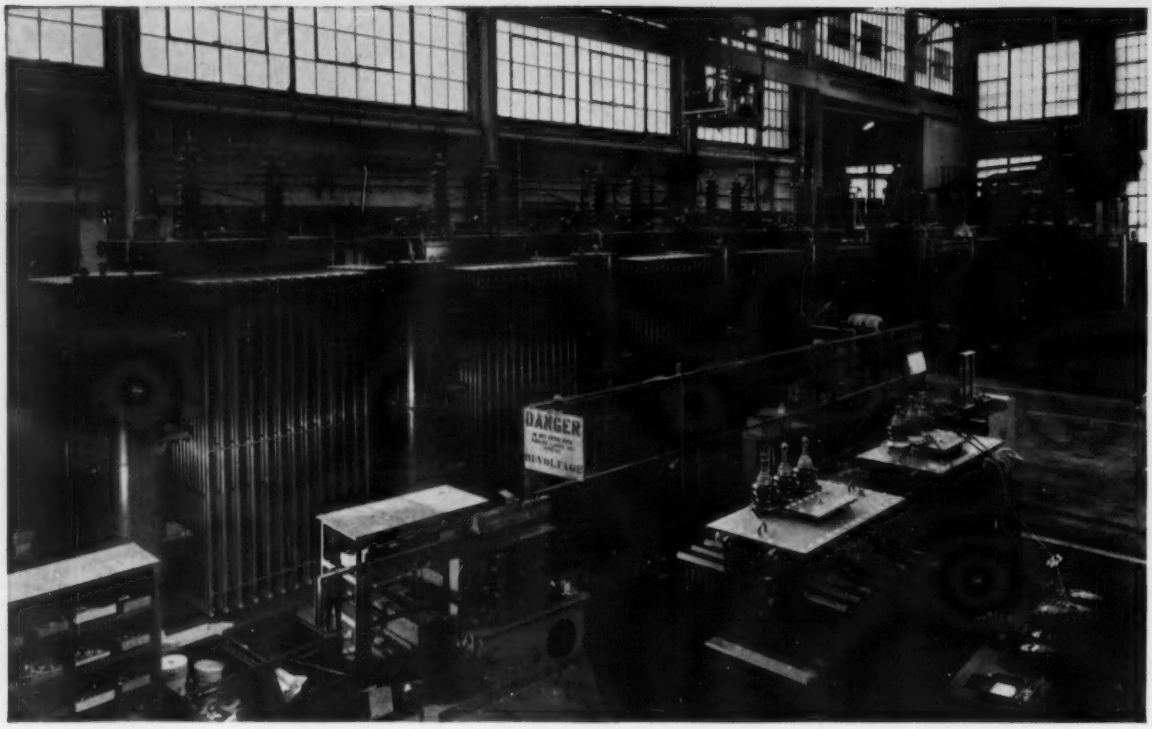
ELECTRICAL ENGINEERING

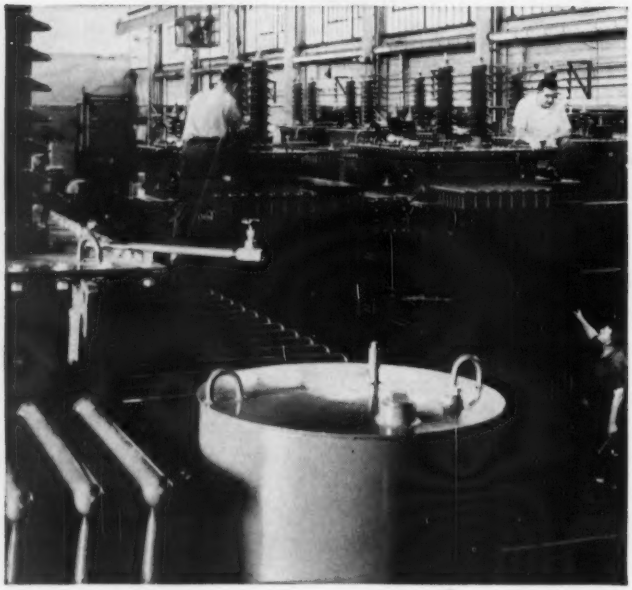
NOVEMBER 1959





SAVE . . . and GET FASTER DELIVERY

with Kuhlman standard ASA power transformers



You save time and money when you order Kuhlman ASA standard medium transformers (through 10,000 KVA, 69 KV). There's little or no engineering time. Production costs are lower. Quality is high and uniform. Delivery is faster. It pays to specify *Standard Kuhlman.*

However, when the job calls for some deviation from the standard, Kuhlman's unique capabilities are even more valuable to you. Here you get engineering and manufacturing flexibility that is able to meet your special needs without delay or undue loading of costs.

Whether your order is for standard or non-standard transformers, you'll get fast service, close pricing, and assured satisfaction from Kuhlman—transformer specialists for 65 years.

Be sure to get a quote from Kuhlman!

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KUHLMAN ELECTRIC COMPANY **General Offices: Birmingham, Michigan**

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ELECTRICAL ENGINEERING

NOVEMBER 1959
Vol. 78, No. 11

75 Years
A Prologue to the Future

THE COVER: 3,600-rpm turbine-generator being built by Westinghouse Electric Corporation for the Helena Steam Electric Station of Arkansas Power & Light Company. Rated at 384,000 kva, the unit will be capable of 10% additional capacity when the hydrogen inner-cooling gas pressure is increased from the normal 45 psi to 60 psi. The completed generator will weigh approximately 500 tons and will be about 42 feet long.

Contents

A Salute to the American Institute of Electrical Engineers — *Henry Ford II* — 1073

Future Research Needs in the Electrical Industry — *E. D. Cook*
Perspective on our real needs, spiritual as well as material, must be achieved for a rational and effective research program — 1074

Instrumentation for Research on Human Performance — *D. B. Hatmaker*
Instrumentation to obtain psychophysiological data to aid spacecraft designers seek a balance in a complex system of men and machines — 1079

Needed: A Forum for Research Philosophy — *Arthur Bronwell*
It is essential for the technical societies to gear their operations to a rapidly changing scene of scientific and technological growth — 1086

Measurement and Influence of Surface Charges in High-Voltage Phenomena — *S. I. Reynolds*
Study of surface charges in high-voltage phenomena has been given new impetus by the use of the rotating probe electrometer — 1090

A High-Capacity Maintenance-Free Generating System for Motor Coaches — *R. L. Larson*
High electric output and long life without maintenance are achieved in a recently developed generating system for motor coaches — 1096

Electrostatic Power Generation for Space Propulsion — *O. P. Breaux*
Advantages of electrostatic generators for ion propulsion in space vehicles include high efficiency and ability to operate in a vacuum — 1102

The Atlantic Cable—Part III. — *Bern Dibner*
This is the concluding installment of a three-part series on the laying of the Atlantic Cable — 1106

Russian Visit to U. S. Computers — *M. M. Astrahan, E. M. Zaitzeff*
Report of a tour of the United States computer installations made by a group of Soviet computer experts — 1112

CONTENTS CONTINUED

Published monthly by American Institute of Electrical Engineers

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effective automation begins before the start with COORDINATED CONTROL

Automatic control, the vital element which helps make automation and its many important production benefits possible, involves much more than top quality control equipment. And for most effective automation, automatic control begins long before the start-up—should in fact be the starting point for automation planning.

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Contents Continued

Technical Paper Digests

Instability in a Conditionally Stable System	*J. L. Douce, R. N. King*	1078
Assessing Delay Distortion Effects in Data Systems	*A. D. Fowler, R. A. Gibby*	1085
Rapid Heating of Dielectric Materials at 915 Mc	*G. E. Feiker, N. C. Gittinger*	1089
Positive Feedback in Servosystems	*Z. H. Meiksin*	1095
Control of Infrared Radiation	*I. J. Barber*	1105

Departments

Abstracts of AIEE Technical Papers	1118
Institute Activities	
Ground Is Broken in New York for New United Engineering Center	1121
Engineers Joint Council Reports on Consolidation Issue	1122
Chairman Elected for New AIEE Division	1122
21 Session Themes Listed for Electrical Insulation Conference	1123
Fortescue Fellowships Are Available for 1960-61	1124
AIEE Future Meetings	1125
Midwest Symposium on Circuit Theory Scheduled December 1-2, Marquette University	1126
E. B. Robertson Honored at Luncheon in Dallas, Texas	1127
Technical Papers Invited for 1960 ECC	1127
Philadelphia Lauds AIEE on Its 75th Year	1128
Index Provides Summaries of Engineering Publications	1128
6th Electrical Conference of Petroleum Industry Held	1129
Subcommittee Formed on Electric Power Sources	1129
AIEE Kansas City Section To Participate in MAECON	1130
Committee To Nominate Officers for 1960 Election	1130
AIEE Fellows Elected	1131
AIEE Personalities	1132
Obituaries	1137
Of Current Interest	
Visible Record Computer Designed for the Banking Industry	1138
Panelescent Dashboard Lamps Offer Important Safety Advantage	1140
Translucent Ceramic Displays High Degree of Strength, Heat Resistance	1141
Future Meetings of Other Societies	1141
Missiles Launched from Railroad Cars	1143
Direct-Wire TV System for Schools and Universities	1144
Reactor Vessel Pressure-Tested on Site	1145
Lightweight Array Antenna	1147
New Books	1148
Technical Literature	1150
New Products	18A
Industrial Notes	36A
Trade Literature	58A

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Four 2000kw units make up the 8000kw installation recently completed by Perkin for a major chemical company. Other power capacities—up to 100,000 amperes and 800 volts dc—can be obtained easily by connecting units in parallel or series to meet voltage and current requirements. Simple design permits side-by-side grouping of cabinets.

PERKIN SILICON RECTIFIERS CUT YEARLY MAINTENANCE TO MINUTES

Recent installation delivers 8000kw, 625v, has 94-97% efficiency

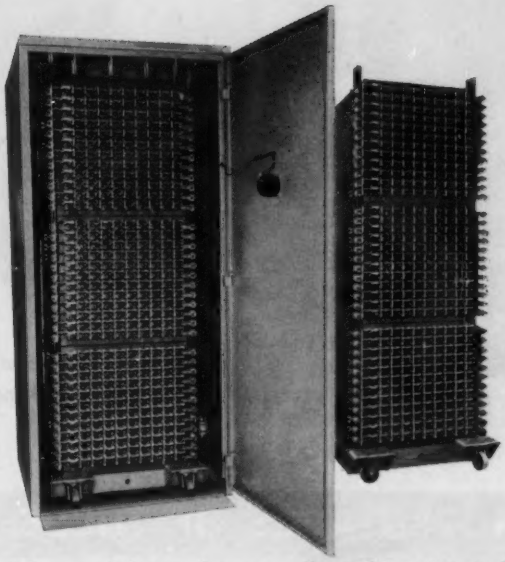
You save from the moment you order all-static silicon rectifier equipment from Perkin. Compared with conventional mercury-arc rectifiers and other conversion equipment, Perkin units cost less initially, cost less to install, and cost less to operate. They do their job more dependably, more quietly . . . at about two-thirds the weight and in less than one-half the space.

The key to this important advance in dc power conversion is the all-metal silicon rectifier diode. This rugged, non-aging semiconductor device eliminates the need for filament power, tubes, excitation, ignition systems, elaborate cooling systems—in fact, removes all the usual reasons for supervision and repair. It makes possible equipment that you can trust completely in unattended locations.

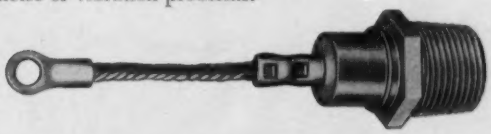
Downtime and overhauls are a thing of the past. You can measure yearly maintenance in minutes instead of days! And thanks to the reliability and stability of silicon, the high efficiency of your Perkin equipment lasts around the clock, through the years.

PERKIN

PERKIN



"Draw-out" feature lets you roll rectifier unit out of cabinet for immediate access to all internal components. Units move easily, install anywhere—need no special foundations or pumping facilities, create no noise or vibration problems.



Non-aging, high-temperature silicon diodes keep equipment efficiency high through the years. Elements are hermetically sealed, bond is metal-to-glass. No organic binders or potting compounds are used.

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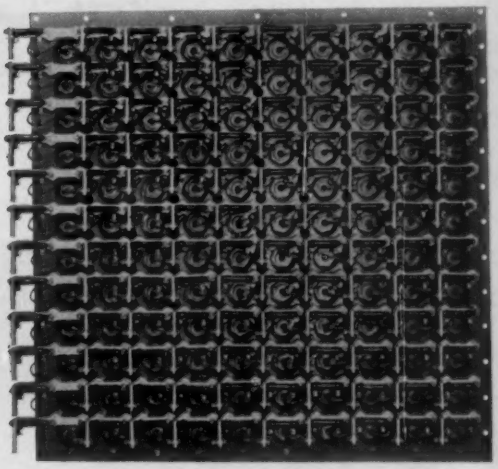
PERKIN SILICON RECTIFIER EQUIPMENT...

is short circuit-proof, has coordinated protection of diode fuse, output fuse and input breaker. Overload protection meets NEMA standards.

Conservative design of Perkin industrial rectifier units assures uninterrupted operation even if one rectifier element or more should fail. Should any *one* rectifier element in a string fail, the fuse does *not* burn out, and the entire rectifier unit will continue to operate. Should *several* rectifier elements in a string fail, the fuse *will* burn out to protect the remaining rectifier elements in that string, and still the entire rectifier unit will continue to operate.

Forced balance of voltage and current prevents overloading of elements, eliminates need for matching silicon junction replacements.



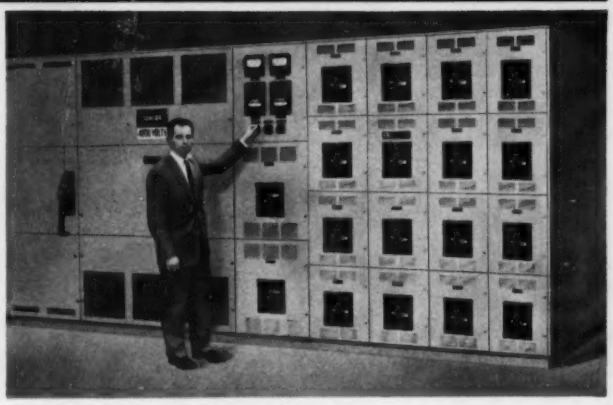
Perkin also offers a full line of standard industrial silicon rectifier units starting at 25kw. Moderate prices, prompt delivery.

Write on your letterhead for detailed technical information, indicating your specifications, or for a copy of our latest technical article, "Industrial Semiconductor Rectifiers."

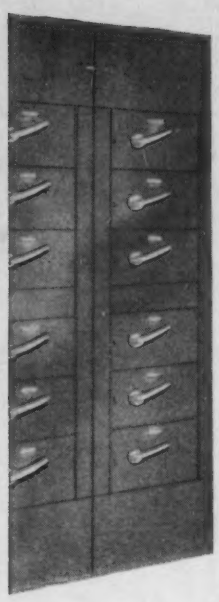
I-T-E Model ETI circuit breakers...
specially designed for motor control centers

GET THE EXTRA ADVANTAGES OF THESE OTHER

Most advanced 600 v power switchgear . . . with new I-T-E K-LINE circuit breakers. Pulldown handle and stored energy mechanism give 5-cycle closure every time. Means longer contact life, greater operator safety, less maintenance. Wide load range trip adjustment saves later modification. Closed door disconnect for safety.



Best coordinated secondary unit substations. Only I-T-E designs and builds complete secondary unit substations in one plant. Engineers work closely together. So you benefit from extra time and money-saving features: better coordinated designs, easier assembly, pretested performance, and delivery to match your own construction schedule.



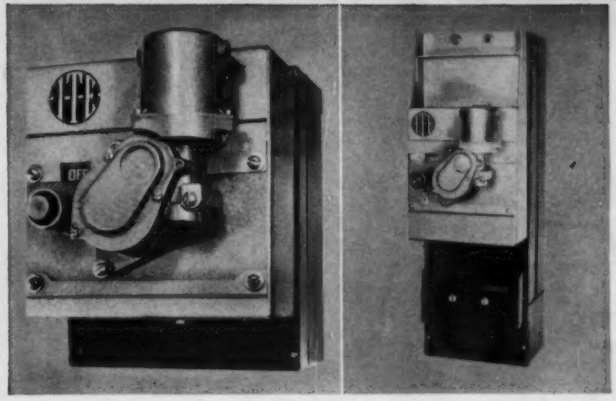
Motor circuits need this PINPOINT PROTECTION

I-T-E Model ETI circuit breakers are special purpose . . . with advantages that motor circuits need for complete protection. Unlike regular circuit breakers, they can be easily set to an instantaneous rating about 11 times normal full load current. This gives instant protection against overload damage without nuisance tripping. Regular breakers are preset at instantaneous ratings as high as 100 times full load current.

Look what this difference means. Take the example of a 20 amp breaker recommended for use with a motor starter for a 500 horsepower 440 volt a-c motor. Full load current is 7.5 amp. An ordinary breaker would have an instantaneous trip setting of 500 amp—many times the desired value. A high resistance fault or short circuit current less than 500 amp could do permanent damage before thermal devices would trip the breaker. But a 25 amp Model ETI breaker in this application would have an instantaneous trip setting of only 87 amp . . . giving instant opening in case of high current faults without nuisance tripping. Model ETI circuit breakers are available in five frame sizes and in ratings up to 800 amp continuous.

I-T-E CIRCUIT BREAKER COMPANY

I-T-E PRODUCTS TOO



TELEMAND* . . . Molded case economy . . . remote control luxury. Now I-T-E molded case circuit breakers are available with new motor operators for remote opening, closing or resetting. Can be easily wired for pushbutton control from a distance. Costs far less than alternative devices. Also permits local or automatic operation.

I-T-E Circuit Breaker Company I-4
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- ☐ K-LINE LV switchgear (600 v)
- ☐ Secondary unit substations
- ☐ TRANFO-UNITS†
- ☐ TELEMAND motor-operated molded case breakers
- ☐ Power switching centers
- ☐ URELITE® circuit breakers
- ☐ Metal-clad switchgear (4.16 and 13.8 kv)

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SPECTACULAR—
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Corona means crown. It can also mean trouble for ordinary high-voltage cable—because corona is also the name for a low-energy electrical discharge (the glow around the crown at left) which actually cracks and splits ordinary rubber insulation. How? By ionizing any air in between and around conductor and insulation, it creates ozone, ultraviolet light, and certain nitrogen compounds.

And ozone, for example, works itself into ordinary rubber insulation and splits the long-chain rubber molecules. In time you see the costly result—cracked insulation and cable failure.

HERE'S ANACONDA'S ANSWER

Butyl—the most effective rubber insulating material ever developed—has inherent resistance to ozone. And—to aging, moisture, and heat.

But—butyl handles differently from other rubbers. Additives, usually in the form of finely divided powders, are extremely difficult to disperse uniformly in the raw butyl. Butyl also presents special vulcanizing problems. In short, proper manufacture of butyl insulation requires specialists and specialized equipment at every manufacturing step.

That's why Anaconda built a new plant for just one product—Anaconda Butyl (AB) Cable. The men behind this specialized equipment have but one job too—to study and improve the design and manufacture of butyl-insulated high-voltage cable.

This specialized manufacture and specialized inspection, test and quality control are part of the reason why Anaconda Butyl (AB) Cable means long-range economy and reliability, and why you should specify (AB) to protect your investment in high-voltage cable.

Send for publication DM 5903: High-Voltage Durasheath* Cable to Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.

*Reg. U.S. Pat. Off. 59237

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ANACONDA®

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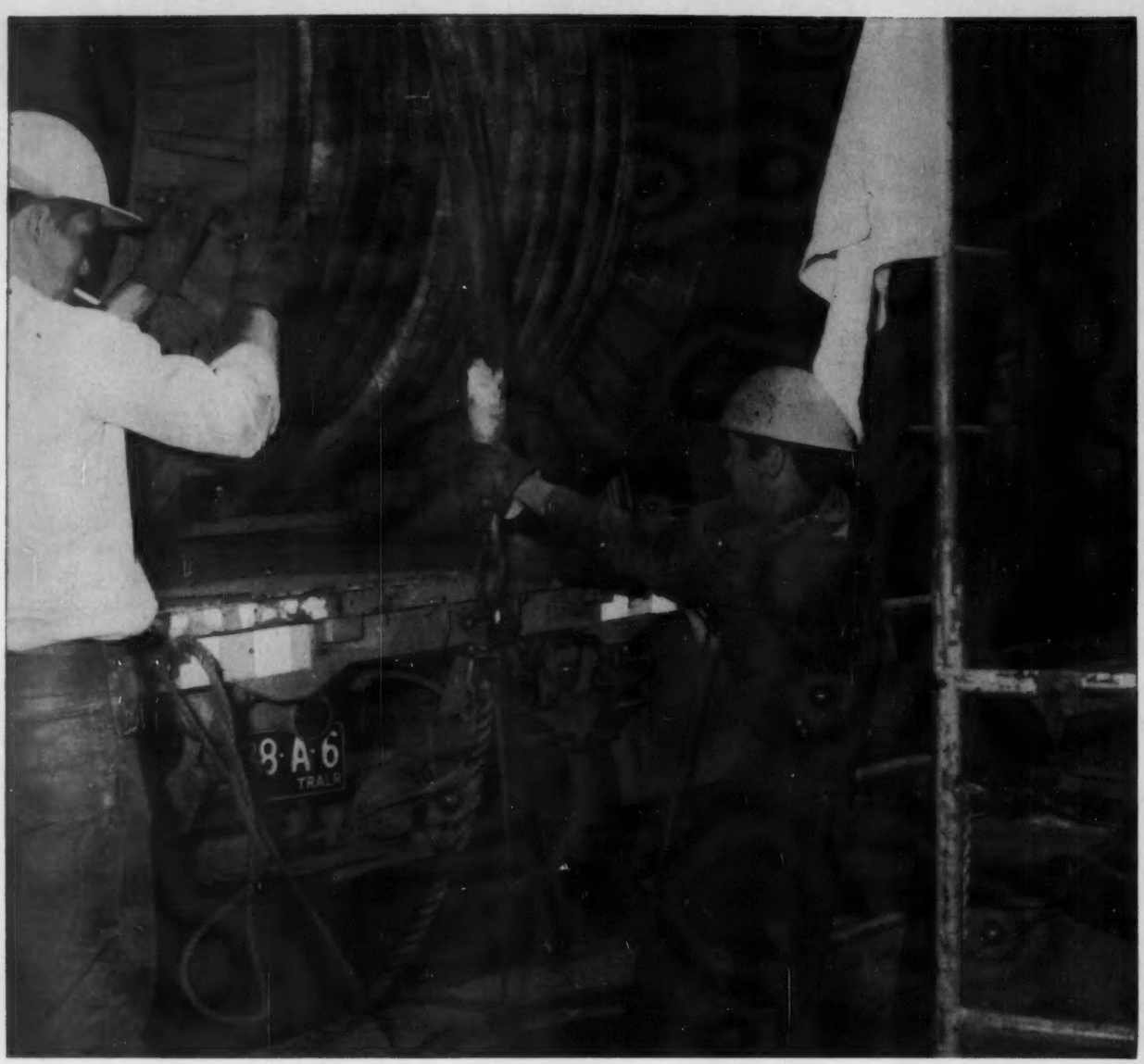

Installing a Tiger Brand 15KV paper-insulated, lead-sheathed, gas-filled cable in big city network to obtain higher capacity and freedom from maintenance.

Making a splice on a Tiger Brand Gas-Filled Cable is about the same as solid cable except for the simple splicing of the small tubes.

USS

Tiger Brand Electrical Wire & Cable

A standard cable for every special job

- Asbestos Wire and Cable
- Mold-Cured Portable Cord
- Shovel & Dredge Cable
- Paper & Lead Cable
- Varnished Cambric Cable
- Interlocked Armor Cable
- Special Purpose Wire & Cable
- Aerial, Underground and Submarine Cable

What's the difference in electrical cable?

You can install and forget a USS Tiger Brand Gas-Filled Cable

Tiger Brand Gas-Filled Cable consists essentially of one or more conductors having a conventional solid type saturated paper insulation and covered with a lead sheath.

It differs from solid-type cable in one important respect—it has small open helix steel tubes in two of the interstices of a three conductor cable to supply gas to the cable structure, and a solid walled copper tube in the third interstice to transmit gas pressure to joints and terminals. These are filled with dry nitrogen gas under a stabilized pressure of about 12 pounds. This system effectively controls sheath stresses, eliminating the major cause of cable failure. Sheath integrity is under constant supervision by the gas pressure monitoring system.

Increased Reliability. Advance warnings are received of any damage to the lead sheath. Moisture entrance to the cable is prevented and repairs can be made of any sheath damage before it has resulted in cable failure. In case of sudden emergency overloads, the pressures from the expanding oil are controlled through the gas feed channels, thus preventing any possibility of sheath rupture due to excessive pressures.

Proved Performance. Tiger Brand Gas-Filled Cables have been in use for many years. They have established a record of continuous performance with very little maintenance. For complete engineering information call our nearest sales office or write American Steel & Wire, Dept. 9286, 614 Superior Ave., N.W., Cleveland 13, Ohio.

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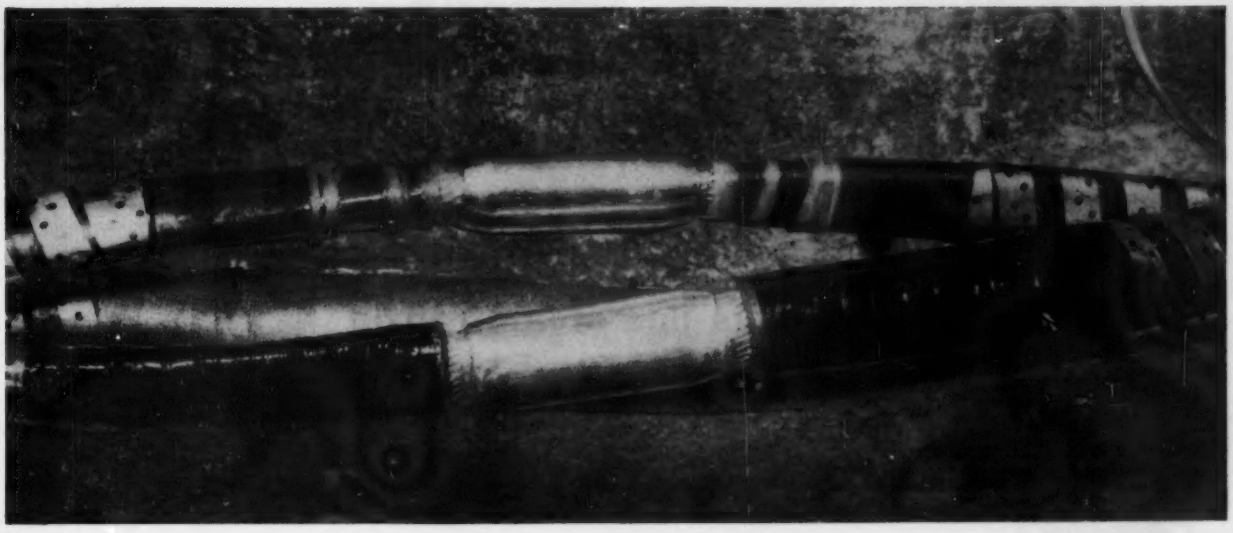

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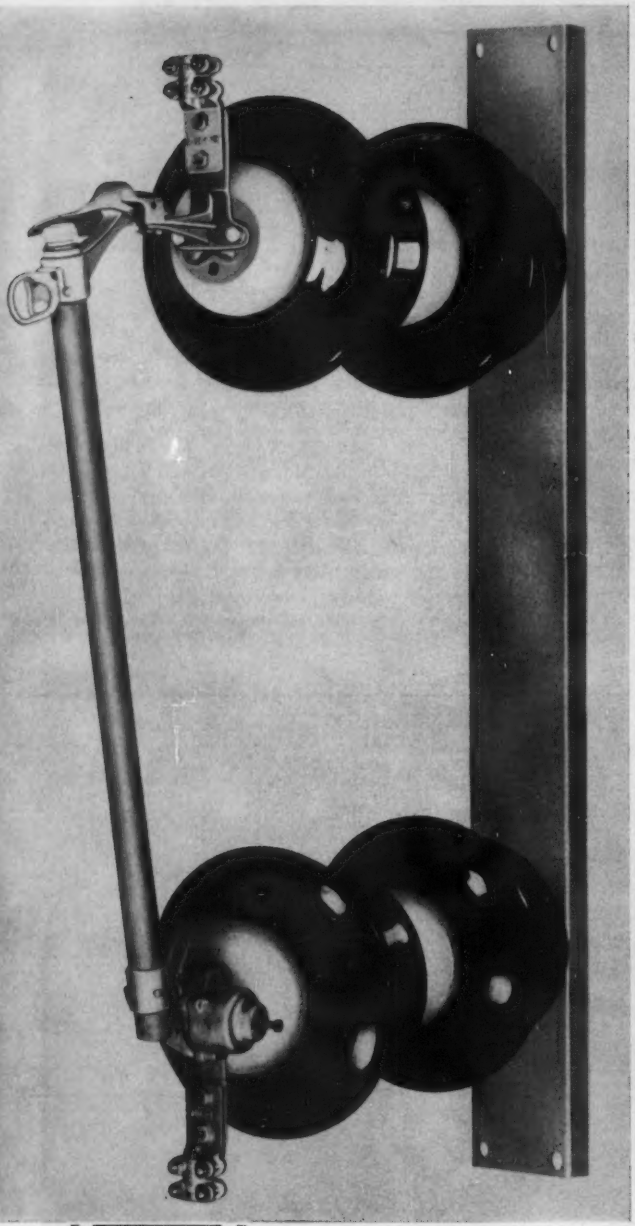
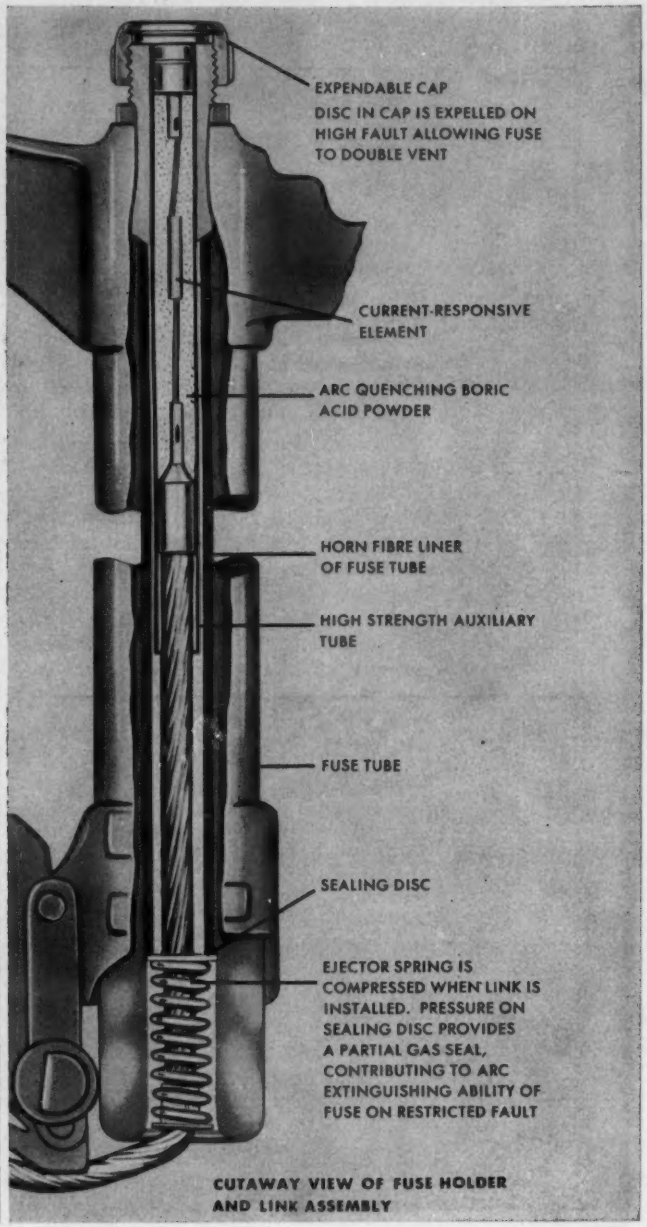
A Reliable New Family of

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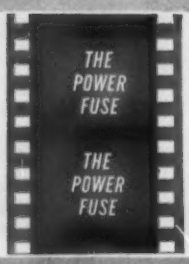
DISC IN CAP IS EXPELLED ON HIGH FAULT ALLOWING FUSE TO DOUBLE VENT
CURRENT-RESPONSIVE ELEMENT
ARC QUENCHING BORIC ACID POWDER
HORN FIBRE LINER OF FUSE TUBE
HIGH STRENGTH AUXILIARY TUBE
FUSE TUBE
SEALING DISC
EJECTOR SPRING IS COMPRESSED WHEN LINK IS INSTALLED. PRESSURE ON SEALING DISC PROVIDES A PARTIAL GAS SEAL, CONTRIBUTING TO ARC EXTINGUISHING ABILITY OF FUSE ON RESTRICTED FAULT

CUTAWAY VIEW OF FUSE HOLDER AND LINK ASSEMBLY



Don't miss this sound movie in full color..."The Power Fuse"

It is available, without cost, for viewing by anyone interested in power fuses. On-the-spot results of field tests conducted in conjunction with a leading utility. Factual, informative, well worth your time. Contact your Southern States representative to arrange a showing, or write direct to the company.

Power Fuses by Southern States

- POSITIVE CLEARANCE OF RESTRICTED FAULTS
- HIGHEST INTERRUPTING RATINGS AVAILABLE
- WIDEST RANGE OF SELECTION
- SIMPLIFIED CONSTRUCTION

Reliable performance—to provide dependable protection against high or low fault currents—is one of the most important requirements demanded of power fuses by engineers. With this uppermost in mind, we developed our new family of power fuses.

Extra reliability in clearing restricted faults is provided by the new, dual-operating characteristics of the expendable cap and arc-quenching boric-acid fuse link.

Extra reliability in handling high faults is provided by the double-venting action, fibreglass tubes and other design features—resulting in interrupting ratings approaching 3½-million kva at 161 kv.

A wider range of selection permits adequate fusing without buying excessive interrupting capacity.

The expendable cap and the sealing disc at the lower end of the fuse prevent the entrance of moisture or extraneous matter. Patented electrostatic shielding eliminates corona damage. A built-in snubber brings the fuse holder to a cushioned, shock-free stop. All in all, this rugged new family of power fuses is engineered to provide completely reliable service for many years.

Get the full story from your Southern States representatives, or write for Bulletin 59PF.

RE-FUSING IN THE FIELD IS QUICK WITH SOUTHERN STATES FUSE KITS

Economical fuse kits, with all of the components necessary for re-fusing in the field, are available for all Southern States Power Fuses. Four speed ratios—clearly marked, compact packages.

PIONEERS IN POWER FUSES SINCE 1924

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THOMAS JEFFERSON BUILDING

Electrical services are fed from two 4,000 amp. main distribution boards. Each of the main switch boards is fed by 8-500 MCM conductors per phase.

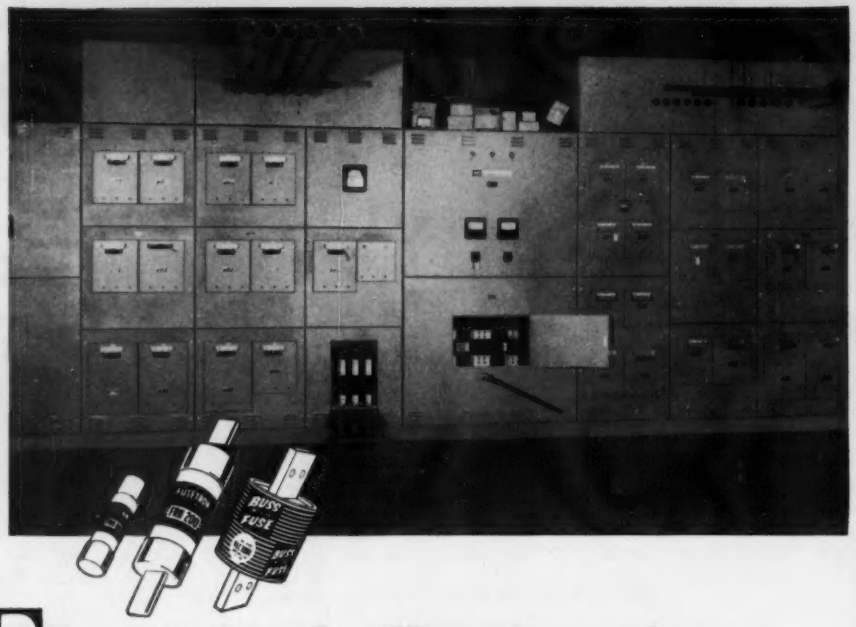
Switch Board #1

Protected by: 3-4000 amp. BUSS Hi-Cap Fuses . . . 12-600 amp., 30-400 amp., 3-200 amp. FUSETRON Fuses.

Switch Board #2

Protected by: 3-4000 amp. BUSS Hi-Cap Fuses . . . 6-600 amp., 33-400 amp., 39-200 amp. FUSETRON Fuses.

All distribution panels protected by FUSETRON dual-element fuses.



Electrical Protection goes MODERN *with* BUSS Fuses

in St. Louis' Newest Multi-Storied Office Building . . .

The Thomas Jefferson Building is another outstanding example of BUSS Hi-Cap and FUSETRON dual-element fuses meeting the requirements for a modern protective device for use in modern electrical systems.

Today's electrical networks, with their tremendous capacities, have emphasized the need for a superior protective device that can be relied on to safely and dependably handle faults of great magnitude.

BUSS Hi-Cap and FUSETRON fuses, because of their high interrupting capacity and life-time dependability have become the natural choice in both new installations and when electrical systems are being modernized.

WHY HIGH-INTERRUPTING CAPACITY AND DEPENDABILITY ARE ESSENTIAL FOR A MODERN PROTECTIVE DEVICE...

CAPACITY

The magnitude of fault current is only limited by the capacity of the transformers or networks. These capacities have been increasing yearly — and most likely will continue to increase.

A modern protective device, therefore, must be capable of interrupting faults of 75,000 to 150,000 ampere which are available today — and be adequately safe to allow for future system growth.

BUSS Hi-Cap and FUSETRON dual-element fuses meet this requirement. The interrupting rating of BUSS Hi-Cap fuses is 200,000 rms symmetrical — and for FUSETRON fuses it is 100,000 rms symmetrical.

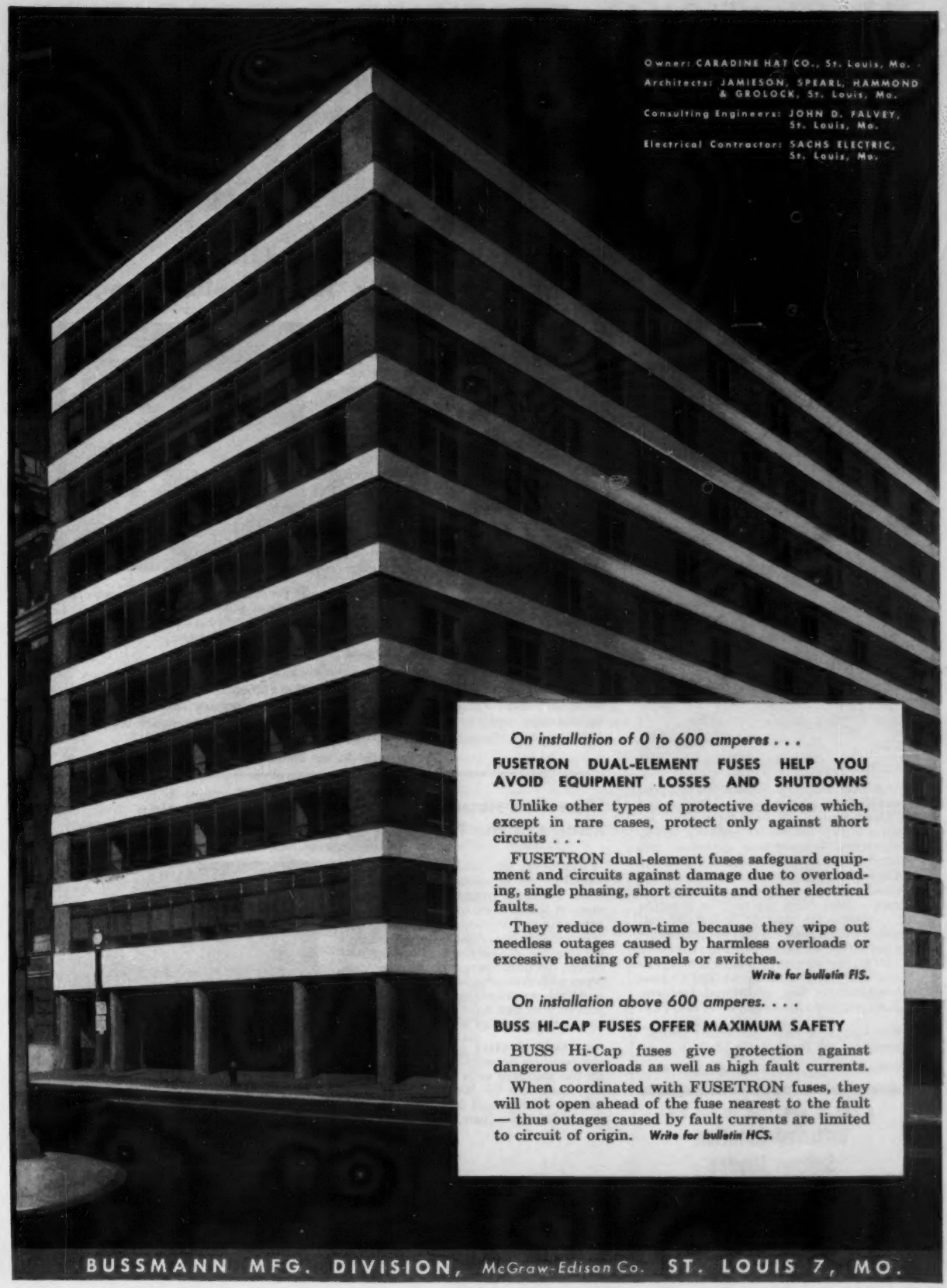
LIFE-TIME DEPENDABILITY

The *Modern* protective device should remain just as safe and accurate through the years as it is on the day installed. Otherwise, how can you be sure it will interrupt these high fault currents should trouble occur 10, 15 or 20 years from now.

This requirement too, is met by BUSS Hi-Cap and FUSETRON fuses — They remain safe and accurate and require no periodic inspection or recalibration, as they have no hinges, pivots, latches or contacts to stick or get out of order.

1159

ANOTHER BUSS HI-CAP AND FUSETRON FUSE INSTALLATION


Owner: CARADINE HAT CO., St. Louis, Mo.
Architects: JAMIESON, SPEARL, HAMMOND & GROLOCK, St. Louis, Mo.
Consulting Engineers: JOHN D. FALVEY, St. Louis, Mo.
Electrical Contractor: SACHS ELECTRIC, St. Louis, Mo.

On installation of 0 to 600 amperes . . .

FUSETRON DUAL-ELEMENT FUSES HELP YOU AVOID EQUIPMENT LOSSES AND SHUTDOWNS

Unlike other types of protective devices which, except in rare cases, protect only against short circuits . . .

FUSETRON dual-element fuses safeguard equipment and circuits against damage due to overloading, single phasing, short circuits and other electrical faults.

They reduce down-time because they wipe out needless outages caused by harmless overloads or excessive heating of panels or switches.

Write for bulletin FIS.

On installation above 600 amperes. . . .

BUSS HI-CAP FUSES OFFER MAXIMUM SAFETY

BUSS Hi-Cap fuses give protection against dangerous overloads as well as high fault currents.

When coordinated with FUSETRON fuses, they will not open ahead of the fuse nearest to the fault — thus outages caused by fault currents are limited to circuit of origin. ***Write for bulletin HCS.***

BUSSMANN MFG. DIVISION, McGraw-Edison Co. **ST. LOUIS 7, MO.**

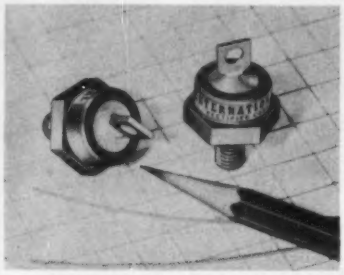
INTERNATIONAL RECTIFIER CORPORATION

RECTIFIER NEWS

Silicon Power Diodes Available to Equipment Manufacturers Free of Charge on New "Test Sampling" Program

"Quad-Sealed" 25 Amp Silicon Diodes For Commercial Applications

Here is a complete series of 25 amp silicon rectifiers designed specifically for commercial applications. Years of research and thousands of hours of testing and evaluation have gone into the development of this series . . . the most thoroughly engineered devices of their type.



A new technical advancement in the sealing of silicon junctions termed "Quad-Sealed" (a four layer seal) assures high resistance to humidity, shock, vibration, temperature extremes and other adverse environmental conditions. Diodes in this series feature an oversized anode lug which efficiently removes heat from the rectifier junction . . . allows the unit to withstand unusually high peak current surges. Stable operation at base temperatures to 130°C, low reverse leakage currents (10 ma, full cycle average at 130°C base temperature) are additional features. Ratings: 25 to 35 Amps, 50 to 500 PIV.

For complete data on "Quad-Sealed" rectifiers, ask for Bulletin SR-310.

CIRCLE READER SERVICE CARD NO. 8

6 AND 12 AMP * 50 TO 500 PIV

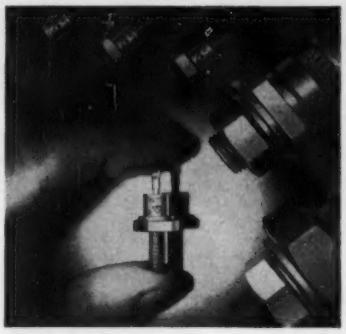
Diffused Junction Silicon Diodes

Ask For Bulletin SR-308

If you are an equipment manufacturer with a need for truly reliable industrial power rectifier diodes, take advantage of this opportunity to test this quality line in your plant . . . at no cost whatever!

The versatility in types, ratings and mounting configurations manufactured by International Rectifier, coupled with *field proven reliability* and high efficiency can add up to a simplified, more dependable design for your power rectifier equipment. Mechanical interchangeability with other available types makes quick changeover possible . . . enables you to benefit in *performance* from our advanced design, manufacturing and test techniques, developed to meet the most rigid military requirements . . . now used in the production of *all* power diodes.

You are invited to investigate the increased efficiency and savings these rectifiers can bring to *your* equipment. Write to our Manager of Industrial Sales describing your application and the voltage/current requirements of your equipment. Your samples will be on their way upon qualification of your application requirements.



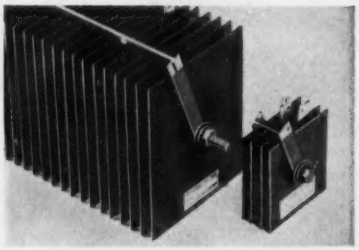
Power diodes are now produced in nominal base current ratings of 6, 12, 25, 45 and 70 amperes with PIV ratings from 50 to 500 volts.

CIRCLE READER SERVICE CARD NO. 9

New Developments Broaden the Application Range of the Toughest of Rectifiers . . . Selenium!

Engineers who really know will tell you that the selenium stack is a veritable "brute for punishment!" Over the years it has proven to be the most dependable and versatile rectifier for the greatest number of power applications. Progressive developments at International Rectifier have resulted in cell types with distinct advantages to equipment where selenium has consistently proven best and have also opened new areas of application where it will excel.

HIGH CURRENT CELLS now deliver twice the rectified dc output per sq. in. than do the standard cells . . . again reducing stack size by 50%. High inverse voltage ratings and low forward drop are additional advantages.



STANDARD "HVC" SERIES NOW IN STOCK — 25 standard stack configurations in center tap and single phase bridge circuits utilizing high current, high inverse voltage cells are now available from stock of the International Rectifier Authorized Dealer in your area.

Ask for Bulletins SR-152 and SR-160

CIRCLE READER SERVICE CARD NO. 10

FOR SAME DAY SERVICE ON PRODUCT INFORMATION DESCRIBED ABOVE, SEND REQUEST ON YOUR COMPANY'S LETTERHEAD

EXECUTIVE OFFICES: EL SEGUNDO, CALIFORNIA • PHONE OREGON 9-6281 • CABLE RECTUSA
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Photo by Philippe Halsman

A Salute to the American Institute of Electrical Engineers

We in the automobile industry salute the American Institute of Electrical Engineers on the occasion of its 75th Anniversary. Your contributions to our nation's unprecedented technological growth deserve the recognition of all industry.

Throughout its history, the AIEE has both guided and reflected the progress of electrical engineering. Its activities have contributed measurably to the advancement of the profession and to its position in modern technology.

But if technology as a whole has gained by these contributions, so especially has the automobile industry. The co-operative efforts of our own engineers with men in allied electrical fields have resulted in many important improvements in automotive products.

It was electrical engineering development that brought automobile electric systems from the old magneto and hand-made spark plug to today's integrated systems of generating, regulating, storing, and distributing electric energy. What's more, it was the rapid growth of electrical engineering specialties that made possible tremendous new advances in automobile production methods.

I am sure that, in the future, automotive technology will rely increasingly upon electrical engineering contributions such as radar sensing controls and applications of thermoelectric principles in heating, cooling, and generating.

This greater reliance should find members of our industry, in turn, playing an increasingly greater part in the activities and objectives of the AIEE. The response of our electrical engineers to the planned United Engineering Center in New York, for example, reflects their interest in your plans and their wish to be a part of them.

In this, its 75th year, the AIEE can take a great deal of pride in its past accomplishments and its prospects for the future. We in the automobile industry join in extending our congratulations and our best wishes for your continued success.

Henry Ford II
President
Ford Motor Company

A E E I 75th Anniversary 1884 — 1959

75 Years—
A Prologue to the Future

Future Research Needs in the Electrical Industry

E. D. COOK
ASSOCIATE MEMBER AIEE

Areas of future research must be evaluated in terms of our true needs, spiritual as well as material, if we are ever to obtain a rational and satisfying life.

SOME LIBERTIES have been taken with the subject assigned me for this seminar partly for logical reasons but more particularly because I am more of an observer than an expert in these matters; moreover, the relatively high mortality rate among those who pose as prophets had some influence.

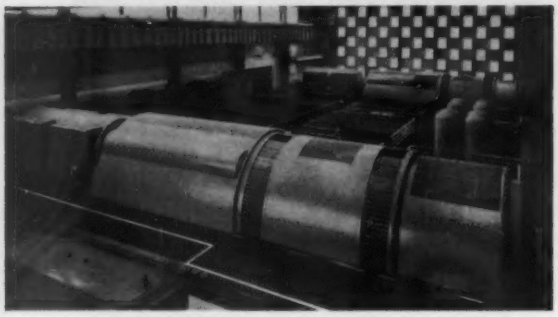


Fig. 1. A modern high-temperature high-pressure steam-turbine generator.

The subject is concerned with the inadequate emphasis on research in two parts of the electrical field; namely, large equipment and electronics. Anything that might be said about the insufficiencies in knowledge involves opinion on what is adequate and what is not—on what will be important and what will not. Since there is no such thing as complete knowledge, there must always be some inadequacy in the state of knowledge at any given time. There is one form of inadequacy however, which may be of more serious concern; that is where an important, immediate purpose is not served because of it. In any general discussion of such matters, one soon becomes involved in questions about the distribution of the available funds, of the available manpower, or with the importance of one objective as compared to another.

BULK-POWER GENERATION

THE FIRST PART can be covered by considering the subject from the viewpoint of bulk-power generation. In the immediate future, will research on the phenomena involved in large generating machines be as fruitful as research on other means of developing electric power? I cannot give an assured answer, but it seems that ultimately man will need other sources of power. The fact is, that no other power-generating means has reached the stage where it can immediately replace the steam turbine for the economical generation of large amounts of electric power. Hence, one may be certain that both approaches will receive attention simply because both the near future as well as the far future must be considered. The most promising other source of energy for such purposes today involves nuclear processes. But neither fission nor fusion processes seem to be destined to replace the present form of power plants in the immediate future. Of the two, fusion is further in the future since only the fission process has been demonstrated to be possible, although not yet competitive, with present bulk-power methods. It is generally agreed, however, that it would be suicidal to neglect either of these ultimate possibilities.

OTHER POSSIBLE SOURCES

IN ANY DISCUSSION of the use of other forms of energy for this purpose, the possible use of solar energy must be considered because of the large amount of heat which reaches the earth. Here also, several new developments are needed. One is a vast improvement in energy converters and the other is vastly superior, large-scale energy storage means. Better energy storage means are

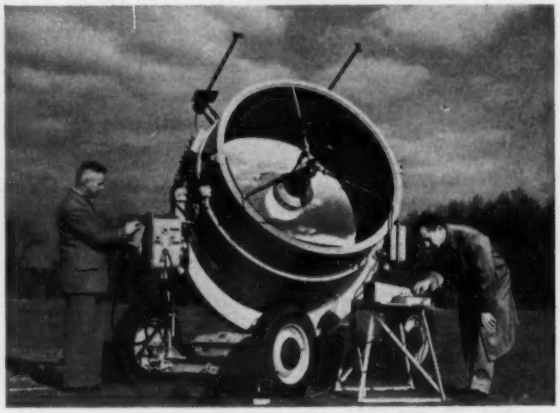


Fig. 2. An experimental solar furnace for generation of electricity by means of a thermionic generator developed by RCA.

Essentially full text of an address presented at the "Seminar on Electrical Research in the West" held during the AIEE Summer and Pacific General Meeting, Seattle, Wash., June 21-26, 1959.

E. D. Cook is with the General Electric Company, Schenectady, N. Y.

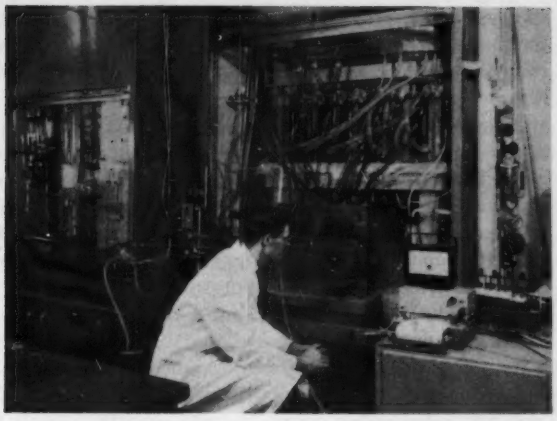


Fig. 3. An experimental fuel cell for generation of electricity using oxygen and hydrogen as fuels.

for currently known materials at least, there are practical obstacles in the way of such means for generating the large amounts of electric power which our central stations must furnish.

The thermionic converter, which is something like a vacuum tube, offers an efficiency in the foreseeable future of approximately 20%. Thus, it too is not an immediate contender for the place of the present power-generating equipment in modern central stations.

Why then do research people put emphasis on these things? For two main reasons. First, knowledge is an end in itself and secondly, there are other foreseeable uses for such devices where bulk power is not the sole objective or where efficiency is not of primary importance.

Do these facts mean that research is presently insufficient or inadequate? I don't know, because when an idea which offers substantial hope of successful exploi-

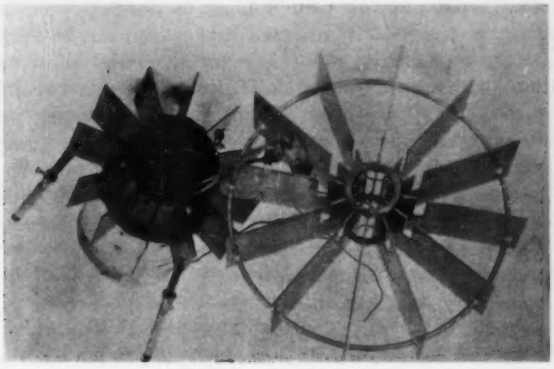
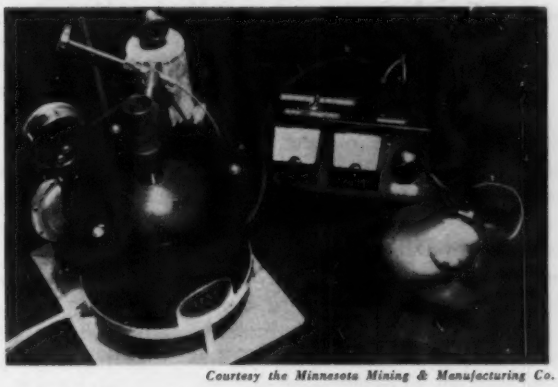


Fig. 4A. An experimental thermoelectric generator.



Courtesy the Minnesota Mining & Manufacturing Co.

Fig. 4B. A propane gas-powered thermoelectric generator.

needed also in many other applications, but the present rate of progress does not seem to be sufficient for our needs if solar energy is to be used for generating bulk electric power. Real financial savings could be achieved in other fields. For example, if substantial improvements could be made in electric energy storage means in transportation, real savings could be effected since the power distribution system for electric locomotives and other such vehicles could be dispensed with. Nevertheless, it is debatable whether additional research here would be as fruitful as the same effort applied in other fields. When to place emphasis upon a subject is often as important as what to place emphasis upon.

Among the other possibilities to replace large, rotating electric power-generating machines which are now being closely examined, are fuel cells, thermojunctions, and thermionic converters. Although the fuel cell has a comparatively high efficiency (in some cases as high as 70 to 80%), presently known fuels for such cells offer some serious obstacles. Either it costs too much to get them in usable form or they do not lend themselves to prolonged or efficient use.

The thermojunction is in a similar situation. Even semiconductors offer efficiencies of only 10 to 20%; so

Fig. 5. A thermionic converter (of the vacuum type) shown running a motor, with "pinwheel" attached, from the heat which is supplied by a blowtorch.

tation is not available, no one can foretell when such an idea will come with extra effort, or indeed, whether it will ever come. In such a situation, one sensibly devotes some effort to improving what is now being used This means research will try to improve knowledge in the customarily used forms of large power equipment and this applies to electric power utilization and distribution as well as to its generation.

In the effort now being applied in these directions, a great deal of work is being done in the field of superconductivity. The materials now available require temperatures within a few degrees of absolute zero. These low temperatures are not obtained without considerable cost. To render entire power systems (for generation, transformation, or transmission), such as we now have, operative at these temperatures would be so costly with known techniques and materials that we could not afford them regardless of what they could do. If materials were available for use at the temperature of liquid nitrogen, perhaps we would be in business. Here again, one cannot state with assurance whether the research effort is adequate or not. Certainly existing knowledge in this field has been improved by the work of Professor John Bardeen and the hope is that the burden of the presently required low temperatures may be lifted. The highest temperatures now obtained for useful results is about 18 degrees above absolute zero or —255 C. The best one can do at present is to budget a moderate amount of effort to investigation of the problems involved and hope for success. One fact is certain—no scientific knowledge remains useless. What may be impractical for one field is often entirely practical in another; hence, the results of such work would yield information valuable in other fields.

If I have any predictions to offer, this one stands out; namely, irrespective of current share prices, the electric utility business is one of the best "buys" in the stock market for assured growth of income both now and in the foreseeable future.

Thus, there is an important role for research to play in the existing forms of large electric machines, whether they are power generators or power users. In this connection, it is fruitful to stop occasionally and recall the way things were done yesterday, why these ways have been superseded and even more importantly, how those who clung to the existing ways too tenaciously have often suffered financial loss. The means of improving the present performance of power-generation equipment may be a slow, and probably will continue to be a nonspectacular procedure. New knowledge in the fields of magnetism, mechanics, and chemistry (including that of lubrication, combustion, and insulation) will continue to raise performance, perhaps not as much as in the past, but by real and worthwhile amounts nevertheless. The sum total of these may be revolutionary in a final analysis. Certainly the steady increase in steam temperatures and pressures has been slowly and even painfully achieved, but the substantially higher efficiencies now available in the industry's present power generators are the results. To go further in this direction—say to 1,400 F and 5,000 psig (pounds per square inch gauge)—is not impossible but appears costly at this time due to the new materials needed and their machining.

Many other bits of evidence point to the fact that the future of research in this field is not hopeless. Just when there seemed to be an upper limit on capacity per machine, conductor cooling came along to remove this limitation or at least push it to higher ratings. The effort that has been put forth on thrust bearings for hydro-generators and lubrication for all classes of large machines has already yielded substantial improvement over performance at the time when I spent a few short years as an electrical machine designer. Insulation has been so improved that today a generator or motor coil slot has more current carrying capacity than when I was concerned with such matters, some 35 years ago. Moreover, the reliability has been improved too.

We have seen how conductor cooling has lately become an important factor. There is the present hope that the new doubly oriented silicon iron can be available in quantity to reduce present losses and allow the use of higher flux densities. To recognize that existing knowledge is insufficient and to conclude that this justifies greater immediate effort are not the same thing. The economics of the situation is our only present guide. In this connection, it is believed that our gross national product could very well support somewhat greater efforts in research and that the future may very well prove that this was necessary.

AREAS FOR ELECTRONICS RESEARCH

IN THE OTHER FIELD that was assigned to me—that of electronics—we have seen research yield new industries. The electron tube has made radio communication something quite different from the wireless telegraph of my youth. Broadcasting and movies and, indeed, television are the modern results of previous research effort. Who can say whether or not another "transistor," now only about a decade old, would result from more emphasis on some other phase of the electronic science. Indeed, it is not improbable that if more research effort had been given to the reasons for some of the earlier lack of sufficient reliability for the vacuum tube, the advent of the transistor might have been delayed.

In considering the inadequacies of present knowledge, it is pertinent to ask what are the greatest needs today. We have tended to overlook our various basic needs for such things as air, water, etc. Can electronics help in such matters; for example, can it or some other electrical process provide us with cleaner air for personal health and industry or with a more suitable balance of humidity in both winter and summer? Can electronics coupled with electric power, control humidity? Can such means reduce the problem of the common cold? Can they aid in cleansing the air from disease? Is research here inadequate? We have seen feeble efforts in germicidal lamps and air purifiers, but these efforts are not consistent with our needs. Most of us feel that electricity can become part of the solution,

if not the complete answer, to the problems mentioned.

There is a definite need to know if better ways can be found to prepare our cooked foods to retain more of their health giving and nutritional properties. It is generally agreed that water can leach away vitamins. Nutrition experts recommend that cooking should leave no water which will be thrown away. It is also well known that in certain foods, prolonged, high-temperature cooking can inactivate specific enzymes and leach or decompose certain vitamins, and, in the case of such foods as pork and beef, sterilization against the trichina worm or tubercule bacillus is possible by the combination of the proper temperatures and duration of heating. However, there seems to be a curious dearth of exact knowledge of whether the unique abilities of r-f cooking can be used more beneficially than ordinary forms of heating to combine these diverse objectives. Neither is there much information on whether foods so prepared are as appetizing. In fact, cooking itself is more of an art than an exact science.

Returning to the industrial field, the question might well be asked, "What effect does environment during manufacture have on reliability and performance?" It is known that the performance and life of papers used in electric devices can be affected by the water used to make them. When roughly a 100-to-1 change in conductivity can be made by one distillation process for ordinary tap water and when one ion exchange process can reduce conductivity as much as 27 successive redistillations, one needs to know more about the effect of such matters on products which use water in their manufacture. It is also known that organic acids, abrasives, and certain lubricating oils with inhibitors can affect the life of the thrust bearings used in hydro-generators, but what about those other electric and electronic devices where improvement in reliability is now greatly needed. In general, designers of electric systems have very little exact knowledge of the effect of variations in the various combinations of the possible operating conditions on the life of the components they use. As a result, they must either depend upon an "historic" approach where the past average is the only guide, the "take a chance" approach, or over-design. Certainly more knowledge is needed in this field.

Those in the communication field are well aware of the effects of mathematical research in what is now known as "information theory." Attention has been extended to all forms of information handling and today much of the automation of industry is directly an information handling problem.

An entire new industry—computers—has grown out of the business of handling information. I would be hard pressed to say what fundamental research is needed in computers. Present needs here are more likely to be in the advanced development field; this could include finding out what industry's real needs are and providing for them. Of one thing I am certain: there is a vast need for simpler, smaller, and even slower devices than are now available in this category for the bulk of industry's needs. I personally feel that one of the next needed advances here is for a "print" reader. Such a device could be as common in industry as present digital devices, if for no other reason than that our most accustomed and compact form of information acquisition is by the conventional word rather than the punched hole.

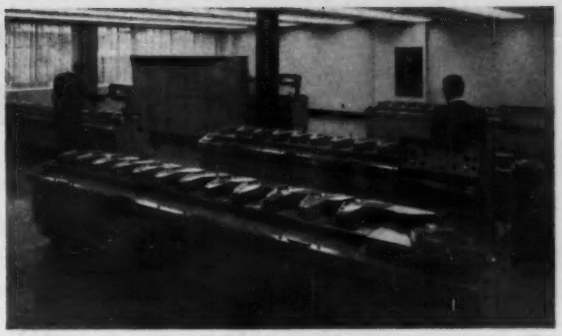


Fig. 6. The GE-100 banking computer.

PERSPECTIVE NEEDED

When it comes to specifying where to place more effort on research, one soon finds either a curious lack of fundamental ideas or is given a list of the more trivial needs which may not need research in its true sense. The fact remains that knowledge of the fundamentals involved in the processes used by the electrical industry has not kept pace with other additions to scientific knowledge. Combustion processes are good examples. We tend to think of an automobile engine as a mechanical affair. Yet when we stop to think that it is an electric spark that starts the cycle and that very little of the gasoline actually entering the cylinder contributes to useful power, we soon realize that here is a simple everyday problem that is consuming our natural resources at a substantial rate and we do not have enough fundamental knowledge of what is actually happening, nor do we know how greatly to improve the situation. Surely the turbine people did not have an easier job in raising the efficiency of their product in the space of time since these two devices became public benefactors. We have not regarded research in this field —that of industrial processes—as important as in what we call "pure" science. Yet we are daily using two of our most precious commodities—manpower and raw materials—at a terrific rate. This alone would seem to justify any improvement we can make in this field by gaining more knowledge of exactly what is happening, the training of more and better people, and, what may be much more important, improving the ability to learn.

Of one thing I am certain: unless ways are found to make advances in the spiritual aspects of our living which at least keep pace with our material advances, it will not ultimately matter whether research in the material aspects of our life is adequate or not. The increasing amount of nervous disorders should be a warning that man cannot live by material standards alone.

Instability in a Conditionally Stable System

J. L. DOUCE

R. E. KING

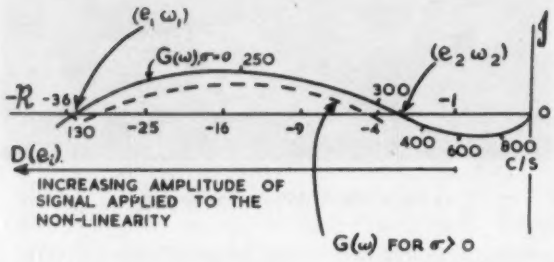


Fig. 1. Nyquist diagram of linear system G(ω) and simple describing function D(e,).

A CONDITIONALLY STABLE SYSTEM is a feedback device which is stable for the designed operating conditions but which becomes unstable if the over-all gain is reduced. When a servomechanism is designed for optimum performance, the final system is frequently found to be conditionally stable. The behavior of this class of systems is reliable, provided that operation is confined to the linear regime throughout.

When overloading occurs in any element in the closed feedback loop, the effective over-all loop gain is reduced, so that the tendency toward continuous oscillation is increased. Any form of input signal to the system can produce instability, provided that its amplitude is sufficiently large.

A particular case of practical importance arises when the input signal is sinusoidal, producing a sinusoidal signal applied to the saturating element. The resultant oscillations of the system depend on the amplitude and frequency of the applied forcing signal. These oscillations may, in certain circumstances, persist after the applied signal is removed, or may be dependent on a forcing signal for their existence. The frequency of the oscillation is, in certain cases, independent of that of the input signal.

Several distinct phenomena are observed in the class of system considered. In addition to the "jump" effect, and subharmonic resonance, oscillations can occur at two distinct frequencies, both unrelated to the input frequency.

To assess the natural stability of nonlinear systems, the describing function technique is used to give an accurate and reliable guide to the resultant closed-loop oscillations. Fig. 1 shows the open-loop frequency response locus of the conditionally stable system considered together with the describing function for a saturation-type nonlinearity. Oscillations can occur wherever these two loci intersect. It may readily be shown, however, that, of the two intersections shown in the figure, only that of amplitude e_1 and frequency ω_1 represents a stable oscillation.

When a sinusoidal signal is applied to the system, the resultant waveform at the input to the nonlinearity will consist of two frequency components, one resulting from the input signal to the system and the other from the oscillations of the closed loop. These two signals will not necessarily be of the same frequency, so that it is no longer legitimate to assume a pure sinusoidal signal at the input to the nonlinearity.

The effect of an applied signal on the oscillation of the system can be evaluated by assuming an input signal to the nonlinearity of the form

$$e_i = ah \cos(\omega t + \phi) + bh \cos n\omega t$$

where the first term represents the effect of the applied signal and the second is caused by the resulting oscillation.

The gain of the nonlinearity to the fundamental signal depends on the frequency ratio n, giving several distinct classes of oscillation. Evaluation of the response for $n = 1/3$ predicts the occurrence of subharmonic oscillations, and for $n = 1$ the jump effect is evaluated. With nonintegral values of n unsynchronized oscillations of the closed loop are considered. These unsynchronized oscillations can be either of two distinct frequencies. The frequencies of these stable oscillations correspond to the two intersections in Fig. 1.

Experimental and theoretical results evaluate the input signals producing the various phenomena in a particular system, and the over-all behavior is as in Fig. 2.

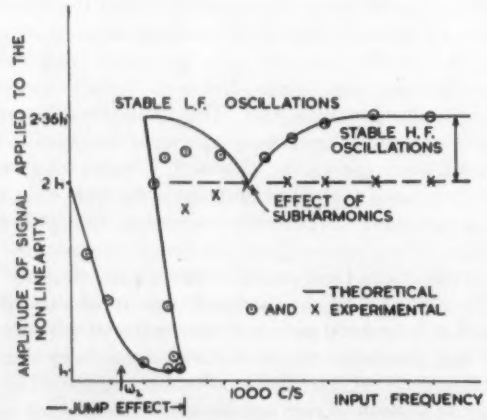


Fig. 2. Composite behavior of the system.

Digest of paper 58-1327, "Instability in a Nonlinear Conditionally Stable System Subjected to a Sinusoidal Input," recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Pittsburgh, Pa., Oct. 26-31, 1958. Published in AIEE *Applications and Industry*, Jan. 1959, pp. 665-70.

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Instrumentation for Research on Human Performance

D. B. HATMAKER

To determine the most efficient role that a human operator can play in spacecraft of the future, instrumentation has been designed that probes psychophysiological reactions to tasks typical of those presently assigned to the human operator in the air. Information obtained can be of help to designers seeking a balance between men and machines in a complex system.

NOW that the role of guided missiles has been more clearly defined in the weapons arsenal of the United States, it has been recognized that manned vehicles will continue to perform military missions aloft. When the age of space travel arrives, many of the problems confronted by the military will apply to scientific ventures. Among these problems is the role of the human operator in the future spacecraft.

Considerable ingenuity has been displayed in the development of complex instruments to perform intricate and exacting tasks. However, the human operator is still unsurpassed in his ability to handle certain emergencies and maintain himself and his equipment.

BACKGROUND

A SYSTEM OF INSTRUMENTATION was designed under U. S. Air Force contract for the study of air crew fatigue during 120 hours of confinement. This instrumentation was developed and made operational for the first time under a second Air Force contract for "Research to Investigate Factors Affecting Multiple Task Psychomotor Performance."

Fifteen subjects, in groups of five, volunteered to learn seven different performance tasks one at a time. Following 3 days of learning experience, they performed the tasks in various combinations. These combinations increased in complexity during the 4 days until as many as five were performed simultaneously. Also during this 4-day period the subject's psychophysiological responses were monitored and recorded for subsequent analysis. The psychophysiological measures were included for the purpose of studying what relations, if any, exist between the activity of the autonomic substratum and observed performance output.

The displays for each of these tests and the operator controls are integrated into a panel, one of which is located at each of the five crew positions in a mockup of an advanced flight station (Fig. 1). This mockup simulates as closely as possible the living and working quarters which would conceivably exist in a space-age vehicle. In order to minimize visual distraction and social interaction among subjects, curtains were placed around each of the crew stations. To mask auditory stimuli, a white noise source of 85 decibels was maintained within the advanced flight-station mockup.

This article will describe each of the performance tasks and the equipment necessary to generate, display, monitor, score, and record the tasks (Fig. 2). The instrumentation required to monitor the psychophysiological measures will also be described (Fig. 3). It represents the latest approach to the requirements formulated by the staff of the Human Factors Laboratory at the Lockheed Aircraft Corporation's Georgia Division and has evolved as the result of more than 2 years of development.

PERFORMANCE TASKS

The battery of performance tasks consists of the following: (1) compensatory tracking, (2) auditory vigilance, (3) warning lights monitoring, (4) arithmetic computation, (5) pattern discrimination, (6) probability monitoring, and (7) scale position monitoring. Each of these tasks is discussed in the order listed.

Compensatory Tracking. The compensatory tracking task consists of a standard aircraft cross-pointer indicator such as is used in ILS (instrument landing systems) instrumentation. The indicator is located at the top center of each subject's panel. Hinged to fold up between the subject's knees is an aircraft flight formation control stick. Signals of random variations are fed into the horizontal and vertical pointers of the indicator. The subject is instructed to manipulate his stick in such a way as to keep the pointers crossed at the center of the indicator. Failure to do so results in an error voltage from each pointer circuit. In order to weight gross errors and thus penalize poor performance, these error voltages are electronically squared by the use of pentodes operating as square-law detectors. The squared error voltage is then integrated over successive 5-minute intervals to obtain on-time performance scores. The scores are displayed by meters on the front of the scoring panels at the experimenter's station. With this method it is necessary to use 10 squaring and integrating circuits which introduce 10 variables into the final scores. These variables are unavoidable in the square-law detector concept since the characteristics of the individual pentodes are not identical. Weighting factors must, therefore, be applied to the meter readout. Proposals for redesign of the on-time scoring circuitry include the use of telemetering commutators and

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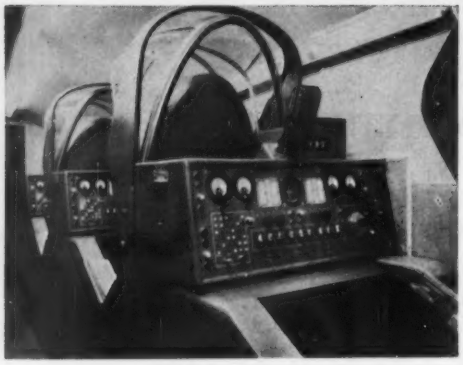

Fig. 1 (left). Interior of advanced flight station mockup showing three of the five subject stations.

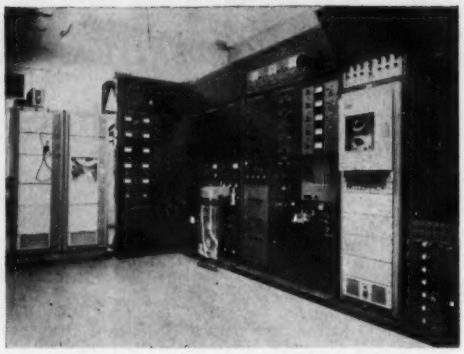

Fig. 2 (right). Experimenter's panels for performance task programming, monitoring, and scoring.

time-sharing on a Berkeley EASE electronic multiplier and integrator circuit.

Briefly, each of the 10 on-time scoring circuits consists of a chopped and rectified input to a square-law detector biased to cutoff. Extremely small plate currents resulting from error voltage inputs serve to discharge capacitors in the plate circuit. A conventional vacuum tube voltmeter circuit is used to indicate the state of charge on these plate capacitors. A downscale reading of the meters at the start of the integrating period of 5 minutes indicates a fully discharged capacitor. As the square-law detector conducts in response to error voltage signals, the meter swings upscale giving an indication of subject performance wherein large errors of tracking count more heavily against the subject than small errors.

In addition to on-time display, an Ampex *FR 114* FM-FM tape recorder is used to record the 10 raw-error voltages. These stored data are subsequently played back, one channel at a time, into a Berkeley EASE analog computer for processing to obtain the integral of the squared error voltages. The channel-by-channel playback of tape-recorded error voltages has the advantage of using a single system of electronics for squaring and integrating. A standby system of tape recording is also available. This system utilizes the subject's raw-error voltages to modulate two subcarrier oscillators.

Auditory Vigilance. The auditory vigilance task requires the subject to monitor, through a single earphone, a beeping tone which occurs every 0.56 second. The tone is normally on for 0.12 second and off for 0.44 second. On an average of eight times in one hour, the off period is increased to 0.55 second. This 25% increase in off time is the cue for the subject to depress a button on his panel to signify that he has detected the change. Two scores are obtained for each subject: the number of correct responses, and the number of total responses.

In order to provide the beeping tone, a free-running multivibrator is used. This circuit serves to modulate the output of a sharp cutoff pentode mixer. A tone of 1,175 cps is fed into the screen grid of the mixer from a tone generator. The output of the mixer is the beeping tone monitored by each subject.

A program of random intervals between significant interruptions is wired into a system of stepping switches and relays. A multicam recycling timer pulses the stepping switches once each minute. When the predetermined interval has elapsed, relays are energized which cause the free-running multivibrator to cut off the mixer for a single lengthened tone interruption. As soon as this occurs the system is reset in preparation for the next selected interval. The subject is allowed 30 seconds to respond to the significant interruption and receive credit for his detection. This allows him adequate time to complete any other task requirement without interruption.

Warning Lights Monitoring. The warning lights monitoring task presents 10 lights to the subject: 5 green and 5 red lights located in pairs on either side of the panel and in the center. The green lights are normally on and the red lights normally off. A push button is placed directly below each light. As soon as the subject notices that a green light is off, he pushes the corresponding button. Likewise, when he notices that a red light has come on, he pushes the associated button. At the experimenter's station there are five scoring panels, one for each subject. Mounted on each panel is a precision electric timer to record, in fifths of a second, the time it takes the subject to respond to the abnormal

Fig. 3. Experimenter's panels for monitoring psychophysiological measures.

condition. Only one abnormal condition is presented to the subject at a time. All timers start running when the programmer initiates the abnormal condition. As soon as the subject pushes the correct button, his scoring clock stops.

As in the case of the previously discussed task, the program of abnormal indications is wired into a stepping switch. A multicam recycling timer governs the presentation and scoring of the task. An average of 10 abnormal conditions are presented each hour.

Arithmetic Computation. The arithmetic computation task consists of 200 problems of simple addition and subtraction, presented at the rate of three each minute. Nine numerical indicator tubes (Nixies), in groups of three, are arranged in a line across the center of the subject's panel. The first three digits must be added to the second three. From this sum the third triad of digits must be subtracted. The subject is allowed 20 seconds to set the last three digits of his answer on a 3-level concentric dial, and the 0 or 1 to be carried, on a 3-position spring-loaded switch. In moving the spring-loaded switch, the subject automatically energizes an anticorrection circuit, which prevents him from changing his answer. At the experimenter's station, scoring panels for each subject accumulate the number of correct solutions, and indicate by lights whether or not the subject has solved the problem correctly. The experimenter's monitor panel displays the problem, and also the correct answer, by Nixies

Stepping switches are used to set up the Nixie circuits through a bank of relays. Only 100 problems are wired into the stepping switches, the second 100 being obtained by a circuit which transposes the relative position, on the subject panel, of the first and second triads of numbers which the subject is required to add; e.g., 123 plus 456 becomes 456 plus 123. A multicam recycling timer is used, as in the tasks mentioned before, to govern the presentation of the problems, the presentation of the answer to the experimenter, and the duration of the answer period.

Pattern Discrimination. The pattern discrimination task utilizes a motorized punched-tape reader to program the presentation of light-matrix patterns in pairs. The light-matrix, consisting of 36 miniature lamps arranged in a block, displays the patterns punched in the paper tape. The second pattern of the pair is rotated by one or more increments of 90 degrees and, in 50% of the pairs, is different. The subject is required to compare the second pattern with his memory of the first, and decide upon their similarity or dissimilarity by positioning a 3-position spring-loaded toggle switch toward SAME or DIFF marked on his panel.

The tape reader and a stepping switch operate in synchronism to transfer the punched pattern to relays. Those relays which correspond to the holes in the tape are energized. A multicam recycling timer: (1) initiates the tape-read cycle, (2) energizes the light matrices through the relay matrix for 5 seconds, (3) advances the tape reader through the second pattern of the pair during a 5-second lights-off interval, (4) displays the second pattern for 5 seconds, and then (5) sets up a 15-second answer period.

The subject, in throwing his SAME–DIFF switch toward his choice, automatically sets up an anticorrection circuit. Whenever the choice is correct, a blue jewel light comes on beside the SAME–DIFF switch to inform the subject of his success.

At the experimenter's station, the score panels indicate by lights whether or not the subjects chose correctly, and by counters the total number of correct decisions. The experimenter monitors the task by a light matrix like those on the subjects' panels, and receives advance knowledge of the correct decision by means of an indicator reading SAME or DIFF.

Probability Monitoring. The probability monitoring task is the most difficult of the four monitoring tasks; which also include auditory vigilance, warning lights monitoring, and scale position monitoring. The difficulty lies in the fact that the stimulus changes are continuous, and that the subject must detect the occurrence of a critical state which is not defined by a single change, as in the other three monitoring tasks.

The subject's instrumentation for this task consists of four 100-0-100 d-c microammeters mounted across the top of the subject's panel, and a 3-position spring-loaded toggle switch located beneath each instrument. At the experimenter's station there are four low-frequency random signal generators (also used in the tracking task), five scoring panels for the subjects, an experimenter's panel containing the programming circuits, and four similar microammeters for bias monitoring. All subject's instruments follow the output of an associated random signal generator, which produces a signal having a mean of zero and a known variance following a Gaussian distribution. Periodically, a bias of known variance is introduced into one of the microammeters at each subject station. The polarity may be positive or negative as determined by the programmer. The fluctuations of the pointer continue to vary as before but around the new mean.

The subject is required to monitor his instruments and try to determine which pointer, if any, is varying about a mean other than zero. When he thinks he has detected such a condition, he throws the associated 3-position switch to the right or left according to his analysis of the mean.

The program is wired into a stepping switch and controlled by a multicam recycling timer. An automatic resetting timer is located on the front of the monitor panel. It provides a 5-minute dwell for each position of the stepping switch, after which it causes the stepping switch to advance. Bias is applied only to one instrument at a time and never with the same polarity to the same instrument twice in succession. The bias is supplied by a special plus 24-volt and minus 24-volt d-c power supply operating from a 3-phase 220-volt a-c line. The bias voltage is attenuated and mixed with the random signal at the terminals of the instruments. There is a damping circuit associated with each instrument which permits only a gradual shift in the mean

position of the pointer when bias is applied. When the subject throws his toggle switch, the circuit from the random signal generator is broken, leaving his instrument to indicate only the bias cr, if he is mistaken, returning his pointer to the center-scale position. The movement of the toggle switch sets up other relays such that when the switch is released and returns to its center position any bias which may have been on that instrument is removed for the remainder of the 5-minute period. Movement of any toggle switch also causes the total-response counter on the subject's scoring panel to register. If the choice has been correct, the correct-response counter also registers. In addition to the two counters, there is a time-to-respond clock on each subject's score panel. This clock will continue to accumulate the time (in seconds) from the introduction of a bias until its correct detection.

Potentiometer adjustments are provided under each of the microammeters on the experimenter's panel which permit him to increase or decrease the magnitude of the shift in the mean displacement of the pointer. The random signal is not applied to the experimenter's instruments.

Scale Position Monitoring. The scale position monitoring task completes the discussion of the battery of performance tasks. The scale position monitoring task is designed to display to the subject four vertical scales which move up and down behind fixed indices. Scale readings increase in both directions from a center reading of zero. At any subject station each of the four scales is graduated differently, but the physical distance from the center (zero position) to the tolerance extremes is identical. The tolerance extremes are printed beneath each scale on the subject panel. Located below each scale is a rotary switch. If the reading on any scale is greater than the printed tolerance limits, the subject is instructed to turn his switch to OUT as marked on his panel. When the scale returns within the printed tolerance limits, the subject must return his switch to IN as marked on his panel. Sensing arms on each scale detect the out-of-tolerance condition and cause an OUT clock on the subject's scoring panel to start accumulating the time it takes the subject to notice the out-of-tolerance condition and position the appropriate switch to OUT. When this is done, the OUT clock will stop. As soon as the scale returns within the tolerance limit, the IN clock on the scoring panel will start accumulating the time it takes the subject to notice the change and reposition his switch.

Just below the five scoring panels are five total-time out-of-tolerance clocks. Regardless of the subjects' responses, these clocks accumulate the total time during which any scale on the associated subject panel is out of tolerance.

The instrumentation used to generate this task consists of four programmers and a program interchange. Each program consists of approximately 50 discrete positions of the scale and lasts for about 15 minutes. These positions are wired into a stepping switch and are random in nature. Only two of the programmers contain out-of-tolerance positions and these do not occur at the same time. The function of the program interchange is to restart the four programmers at the same time and to scramble their outputs to the subjects' scales. As a result of this scrambling, no program is repeated on the same scale twice in succession.

It is recognized that a synchro system offers one of the best means of driving the scales in synchronism with the programmer. The task is currently being redesigned to incorporate self-synchronous transmitters and receivers.

PSYCHOPHYSIOLOGICAL INSTRUMENTATION

THE PSYCHOPHYSIOLOGICAL MEASURES consist of the following: (1) skin temperature, (2) skin resistance, (3) heart rate, and (4) respiration rate.

The instrumentation for the psychophysiological measures is located on the right side of the experimenter's panel. It consists of five Yellow Springs Instrument Company (YSI) Model *47* telethermometers for the detection and display of each subject's skin temperature, five YSI Model *22C* Fels dermohmmeters for the detection and display of skin resistance, five YSI Model *21C* Fels cardiotachometers for detection and display of heart rate, and five Lockheed designed pneumographs for the detection and display of respiration rate. Instrumentation for two other psychophysiological measures—borborygmus and muscular tension—is still in the developmental stage.

The d-c outputs from the above instrumentation were recorded on a 50-channel Consolidated Electrodynamics Corporation (CEC) oscillograph using the CEC Datarite magazine for essentially on-time observation of the measures from each subject. Each subject was allocated one-fifth of the 12-inch width of the recording paper. Within each subject channel, the following trace deflections were established consistent with requirements for adequate resolution in reading: (1) skin temperature analog—24 mm (1.2 C), (2) skin temperature range—2 mm, (3) skin resistance analog—60 mm (10,000 ohms), (4) skin resistance range—2 mm, (5) heart rate—40 mm (40 to 160 beats per minute), and (6) respiration rate—5 mm.

The recording of psychophysiological measures was done at a speed of 1/4 inch per second, which is about half the lowest recommended speed for recording with a Datarite magazine. This was made possible by very close adjustment of the magazine mechanism and the use of a diluted developer solution. As a result, it was possible to obtain four complete test run records on each 400-foot roll of recording paper. Each test run consisted of a calibration trace, 5 to 10 minutes of bioelectric control during which the subjects relaxed, another calibration trace, 1 hour of data during the performance of various combinations of tasks, and a final calibration check trace.

Skin Temperature. The YSI telethermometer is essentially a resistance bridge whose output is fed into a KayLab Model *111A* d-c amplifier and a switching arrangement to select one of 10 subranges. The front

panel contains a meter graduated for 1.2 C full scale. When the subject's skin temperature causes the meter pointer to reach either extreme of the scale, a subrange change of 1 C is effected, thus returning the meter pointer on scale. These subranges are indicated by a pointer on the front panel. They cover the range from 31 C to 39 C. Total instrument range is from 30 C to 40.2 C, or 86 F to 104.36 F.

Skin Resistance. The YSI Fels dermohmmeter is basically a constant current ohmmeter with a range from zero to approximately 500,000 ohms. The instrument is an incremental measuring device in that the total range is divided into a number of equal increments. These are selected by the range switch in such a manner as to balance out the base resistance of the subject individual. Once this initial balance is achieved, changes in the resistance reading of the instrument are changes in the resistance of the subject with respect to his base resistance.

The front panel of the instrument contains a meter graduated to plus and minus 6,000 ohms with zero ohms center scale. Automatic range change occurs at the 5,000-ohm point, thus minimizing the amount of hunting necessary if the resistance of the subject is undergoing small changes at the edge of a particular range.

Since the measured resistance of the subject is closely related to the value of the current flowing through the subject, it is extremely important to hold this value constant throughout the entire range of resistance in order to prevent the instrument from actually influencing the measurement in a varying degree. The Fels dermohmmeter includes a precise constant current circuit using an electronic regulator with positive feedback to maintain the subject current constant at all times.

Heart Rate. The YSI Fels cardiotachometer is a device which samples the time between signals from the heart and converts this to a reading of heart rate in beats per minute as indicated by a meter on the front panel of the instrument. The range of the instrument is from 40 to 160 beats per minute.

The cardiotachometer accepts signals from EKG (electrocardiogram) electrodes placed just under the rib cage of the subject. These pulses are amplified, filtered to remove hum, and amplified again. The *R* wave is selected, shaped, amplified, and used to trigger a monostable multivibrator which closes a relay. It is the operation of this relay that produces the actual timing, or rate determining, function of the cardiotachometer. The relay samples a voltage, which is proportional to heart rate, and charges the holding capacitor which maintains the voltage level until the next heart beat. A coupling capacitor begins to charge in an RC network. The charging of this capacitor is an exponential function of time. The instantaneous voltage to which the capacitor has charged is very nearly a linear function of heart rate. The output stage is a single-stage dual-triode balanced cathode follower. One input grid is connected across the holding capacitor while the other is held at a set value by the balance potentiometer. The front panel meter is connected between the two cathodes of the output stage.

Respiration Rate. The Lockheed designed pneumograph consists of a constant current generator feeding two carbon granule buttons strapped in place around the subject's ribs. Expansion and contraction of the subject's rib cage causes a variation in the resistance of the sensing elements. The resultant signal is fed to the control grid of a cathode follower. The output signal is taken from the cathode follower and indicated by an a-c voltmeter on the front panel.

SUPPLEMENTARY INSTRUMENTATION

IN THE CENTER of the experimenter's station are located several items of supplementary instrumentation. These consist of a battery of five resistance mixers feeding an Ampex *FR1107* tape recorder, a Dage closed circuit industrial television monitor and controls for remote positioning of the camera, controls for an Auricon motion-picture camera which is mounted with the television camera over the advanced flight station mockup, an intercom system, a master timer, a Rycom multitrace oscilloscope and a battery of 13 Hammarlund tone demodulators.

The resistance mixers were originally designed to receive, from each performance task and psychophysiological measure, signals representative of the scores being made by each subject. The Ampex *FR1107* tape recorder was used to store these signals for subsequent playback into the battery of 13 Hammarlund tone demodulators. The outputs of the demodulators were to have been recorded on an oscillograph for analysis.

The closed-circuit television system is mounted on a track above the flight station mockup. A strip of one-way glass permits the experimenter to observe any portion of the interior without the subject being aware of surveillance. The motion-picture camera may be switched on to record any scene of particular interest. The sound track feature of the Auricon camera is used to record comments by the experimenter relative to the scene being recorded on film.

The Rycom multitrace oscilloscope is used to observe any six of the outputs from the physiological instrumentation as they occur.

DATA REDUCTION AND ANALYSIS

THE SIGNALS which are recorded on a 50-channel CEC oscillograph provide the very desirable feature of time correlation between all measures and all subjects. Physiological response data are subsequently reduced utilizing a Benson Lehner Corporation Oscar. The results are tabulated and simultaneously punched into IBM cards. Data from the performance tasks are also punched into these IBM cards.

Data analysis is accomplished by use of an IBM *704* digital computer located in the Lockheed Mathematical Analysis Department. The computer is programmed to determine coefficients of reliability for the various performance tasks in combination with each other. With the introduction of data from the physiological response

instrumentation, numerous cross-correlations are obtained of the factors affecting multiple task performance.

CONCLUSIONS

THE EXPERIENCE which has been obtained in conducting multiple task performance tests on groups of individuals has led to certain conclusions concerning the design of the type of instrumentation described in this article.

1. In any program of a continuing nature, such as the instrumentation for human factors research, it will soon become apparent that it costs less to "go first class" from the beginning. Although this is easy to say, it is not easy to do. One of the more obvious reasons is the matter of financing. Of equal importance, however, is the problem of deciding what is "first class." Cost alone is no criterion of an instrument's applicability to the over-all instrumentation. To be "first class," a piece of equipment or a system of wiring must be as straight forward in design as possible. It should be highly flexible. Equipment should not be limited by a fixed set of operating conditions. Wiring should be done to include spare conductors and adequate junction points or terminals. This will permit rearrangement where necessary and facilitate trouble shooting.

2. If it is necessary to design a piece of special equipment and reproduce it several times, which was the rule rather than the exception in this case, those equipments should be completely interchangeable. All inputs to, and outputs from such assemblies should be made through plugs and receptacles rather than by bringing a bundle of wires to a terminal strip. Within the assembly itself, it is best to incorporate removable subassemblies. While the initial buildup will take longer to complete, it will be more than offset by ease and rapidity of maintenance and troubleshooting. Adequate test points should be provided at easily accessible locations. Making of wires and labeling of components will also facilitate maintenance. Dust covers or blower-ventilated cabinets fitted with filters will pay off in less down time. Finally, a program of component and assembly redundancy should be studied.

3. In designing instrumentation for such specialized tasks as have been described, the designer should explore all possible ways of accomplishing the desired result. Electronics personnel have a tendency to ignore the possible advantages of a relay for certain applications. Similarly, it is easy to overlook some mechanical device such as a cam surface and follower. The use of hydraulic or pneumatic devices may provide the answer to other problems. Whatever approach is taken, it should be with the aim of providing as nearly 100% reliability as possible during the course of the test run. Several of the test programs undertaken in human factors research have operated continuously about 100 hours at a time. Any failure within the test duration may mean the loss of all data from one subject.

4. Another special feature of the instrumentation for human factors research is the necessity of designing repeatability into the programmers. By way of example, consider the compensatory tracking task wherein the subject is required to keep his crossed pointers centered in the presence of a low-frequency random signal input. Consider also that of a total of 30 subjects, only 5 can perform this task at any given time. In order to evaluate accurately the performance of one group of five subjects against the performance of any or all of the other groups, it is essential that each group receive exactly the same pattern of low-frequency random signals. For this reason the use of electronic low-frequency random-signal generators is being abandoned in favor of a cam-type generator which has the advantage of repeatability and which allows the experimenter to insure that the signal is truly random with a Gaussian distribution and a known mean and variance.

5. Everything within reach of the subject must be tamper-proof. Because people are innately curious, they succumb to the temptation to find out what will happen when they turn the head of a countersunk screw or remove the faceplate of an instrument. Their curiosity may cause the malfunction of a task presentation and, thereby, the loss of data from that subject on the affected instrumentation. In addition, the loss of one task presentation may invalidate the data from all other tasks programmed with the affected task.

6. The final conclusion to be drawn is this: expect people to try to cheat. Even in the presence of masking noise and curtains to obstruct the view, subjects have admitted that they have tried to listen for switch clicks as cues and to use overhead reflective surfaces to spy on the actions of their fellow subjects in order to determine on which task to concentrate or in which direction to throw a toggle switch. They have admitted trying to memorize hundreds of math task problems in order to dial in the correct answers on a subsequent presentation of that task. They have tried to correlate the fluctuations of the tracking task cross-pointer indicator with the fluctuations of the probability monitoring instruments even though the former were a combination of two of the latter inputs. Lastly, they have tried to interpret the dimming of a jewel light as a cue to respond to some as-yet-undetected stimulus.

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Assessing Delay Distortion Effects in Data Systems

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AN ESSENTIAL OBJECTIVE of a pulse transmission system is the preservation of some aspect of the pulse shape at the receiver. Phase characteristics of a system, which can generally be neglected in voice transmission, become important in pulse systems, because the shape of a pulse is influenced greatly by the relative phase of the spectrum components. A quantity frequently used to describe this influence is envelope delay distortion. It is a measure of the relative phase shift experienced by neighboring components of the frequency spectrum, and is equal to the slope of the tangent to the phase curve at any given frequency. The object of this article is to illustrate a method for assessing the effects of delay distortion on data-transmission systems, based on experimental tests.

For voice-frequency transmission circuits, many delay distortion curves have the common property of approximate parabolic shape. Since a parabola is defined by three points, it is possible to represent the delay approximately by specifying the delay at three frequencies. The three frequencies chosen in this case were $f_1 = 1{,}200$, $f_2 = 1{,}800$, and $f_3 = 2{,}400$ cycles per second, and the corresponding delay values were designated T_1, T_2, and T_3. Using these values of delay, two quantities, slope, M, and sag, S, were defined. With the delay at f_2 used as a reference, the slope and sag are given as $M = T_3 - T_1$ and $S = 1/2\ (T_3 + T_1)$. These two quantities may be considered as the co-ordinate axes of a plane, on which a parabolic delay curve can be located as a point. Experimental tests were made in which delay distortion was considered on a slope–sag basis, and the performance of a data system was evaluated in terms of these two quantities.

Data-system performance may be expressed in terms of the rate at which errors occur in transmitting the data signal. If the error rate exceeded a certain value (five errors per minute in this case), the system was considered to be "failing," otherwise it was considered to be "working." Errors are produced when either the delay distortion (slope and sag) or the noise power on the transmission line become large, or when various amounts of noise and distortion are present in suitable combination. Tests were made by setting a variable delay network in the transmission path to give a particular slope and sag, and then adding filtered thermal noise until the system failed. The signal-to-noise ratio which produced this condition of failure was then assigned to the point on the slope–sag diagram which represented the particular network. Additional measurements of this type were made for other points ranging over the entire slope–sag plane. Many points were found to have very nearly the same margin against failure, and contours of equal signal-to-noise levels were plotted by interpolation. These contours make up the slope–sag diagram, Fig. 1. In the center of the diagram, the contour lines are spaced relatively far apart. This indicates that when the delay distortion is small (slope or sag less than 600 microseconds in this case) any change in delay has only a small influence on performance. This means that only a small improvement in performance results from delay equalization in this region. In the outer region where slope and sag are larger, however, the influence of delay distortion becomes greater, and equalization has more pronounced effect on the performance of the system. It can also be seen that with the exception of the *H174* loaded cable, all of the transmission facilities indicated in Fig. 1 will perform satisfactorily with a signal-to-noise ratio as low as 20 db.

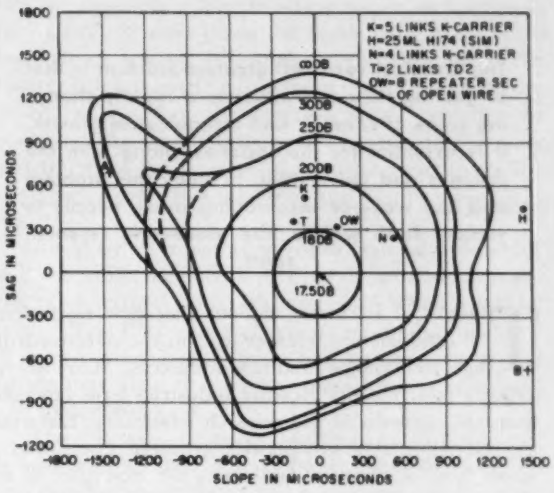

Fig. 1. Slope–sag diagram for vestigial-side-band system, 1,650 bits per second.

This method of mapping the performance of a data system has proved to be a valuable tool. It has provided an organized approach to a complex problem, and results in a clear means of portraying several aspects of a data system in a systematic way. The results presented here are valid only for parabolic delay and for the specific data system tested. The approach, as well as the method of portraying system performance, however, has wide application.

Digest of paper 58-1240, recommended by the AIEE Data Communication Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Pittsburgh, Pa., Oct. 26-31, 1958. Published in AIEE *Communication and Electronics*, Jan. 1959, pp. 918-25.

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Needed: *A Forum for Research Philosophy*

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The technical societies' greatest problem is that of gearing their operations to a rapidly changing scene of scientific and technological growth. It is essential for the societies, along with the colleges and universities, to study this problem and find ways of encouraging young people to venture forth with a true pioneering research spirit.

TODAY it is clearly evident that new discoveries in fundamental sciences lead to the outgrowth of new technologies and new industries. Many of our nation's most rapidly growing industries have emerged from the chrysalis of the research laboratory. Electronics, television, aviation, plastics, synthetic fibers, and a whole host of chemical industries are examples of an almost endless procession of thriving industries in which not only were the technologies unknown 30 or 40 years ago, but also the very fundamental sciences upon which these industries are founded had not yet been discovered.

The rate of advance of this kind of technological development depends upon (1) the rate of discovery of new scientific knowledge, and (2) the time lag between the discovery of new science and its application to new technologies.

Many people are seriously questioning whether either of these is progressing rapidly enough, despite the greatly increased research expenditures. It seems apparent that there are certain constitutional blocks which inhibit both the discovery of new science and its translation into new technology. The nature of these blocks is not difficult to define. It is much more difficult to find ways of removing them. The direction, the progress, and the accomplishment of our nation's scientific and technological growth are inextricably bound up with our ability to understand this problem and to lift the ambitions and the capabilities of our research people, particularly our young people, to higher levels of pursuit and accomplishment.

ROLE OF THE SOCIETIES

THE SCIENTIFIC AND ENGINEERING SOCIETIES, as well as the colleges and universities, play a central role in influencing discovery, both in the development of new science and in engineering innovation. Both groups, I believe, are falling far short of the desirable in providing the kind of research environment and the communication of ideas which will assure rapid advancement in scientific and technological discovery.

New centers of research emerge slowly. Even in today's world there is often a time lag of many years between the discovery of new science and its application to new technology. In certain cases where clear-cut military gains are recognized, Government financing has achieved spectacular results. But the discovery of new science and its exploitation has just begun. Scientists agree that there are boundless possibilities ahead which will yet profoundly revolutionize our industry.

The inertial lag results, in part, from the fact that research effort tends to cluster around certain popularized and heavily explored fields which become self-perpetuating. In these clusters there develops a spirit of progress and a community of interest which magnetically attracts the budding young researcher. In the activities of the scientific and engineering societies he finds an avalanche of discussions, forums, committee meetings, and publications which vindicate his choice of the field. Here he finds a firm footing for his own research efforts.

Much of this research can be characterized as "hole plugging," in that it contributes bits of knowledge, adding to the sum total of knowledge, to be sure, but individually often quite trivial. In the colleges and universities analytically minded faculty members tend to lead their graduate students into the research projects which are discreet, analytical, and have very limited horizons, invariably well within the confines of the well-trodden fields. I do not wish to deprecate analytical research. Not all of it is conventional and certainly we need to make progress in theoretical research.

But I do question—seriously question—the balance between this kind of research and that which reaches out for the larger and more distant goals where there are possibilities of making significant discoveries in new sciences or new technologies. This balance, I believe, is badly out of kilter. Seldom do we find the individual who breaks away from the herd and boldly strikes out on his own for the larger stakes.

THE NEED TO EXPLORE THE FUTURE

THE DIFFICULTY, I believe, in part, is due to the fact that there is no organized forum where research scientists and engineers can deliberately explore the future in a philosophical sense—no place to captivate the vision and the imagination of youth with new ideas which might trigger some of them off to great discovery. Almost everything presented at meetings of the scientific and engineering societies is past tense. A researcher

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completes a study and reports on this at a scientific or engineering society meeting, after which it is duly published in the society journal. With rare exceptions, there is no attempt to project into the future philosophically, and one who indulges in this kind of excursion may find himself regarded as a charlatan. In informal person-to-person discussions in the corridors or over a lunch table, research scientists or engineers are willing to speculate about the future, but this doesn't reach the young people. To get such projections, one must turn to science fiction or to popularized articles in *Life* magazine. One is reminded of the fact that Dr. Robert Goddard, who single-handedly pioneered rocket research for many years before others came into the field, was never invited to present his views or his findings before a leading scientific or engineering society until long after the military importance of his discoveries was clearly established.

Or, to come closer to home, it was not long ago that the AIEE looked somewhat with disdain upon the renegade field of electronics and communications (except for telephone communications) and afforded very little encouragement. Yet this maverick was destined within very few years to become one of the most dynamic and powerful influences in our nation's advancing technological and industrial growth.

If there was ever a lesson to learn from the past it is that again and again new fields of scientific inquiry have suddenly burst forth out of relative obscurity to become dominant fields of technological development within a comparatively short period of time. We have not reached the end of this road. In fact, scientists all agree that the potentialities of opening up new fields are far greater today than ever before.

I suspect that some of the newer scientific societies indulge in far more philosophical exploration than the more staid and established societies. In meetings of the Nuclear Society, the Institute of Aeronautical and Space Sciences, and the Association for Computing Machinery, one finds fluid imaginative excursions into the unknown, creating an atmosphere of excitement leading to rapid innovation. Many of the ideas become inert or lead down blind alleys, but this is the price one must pay for progress. The whole tone of such a society—its quickened pulse, its eager searching into the future of science, its exciting mutual stimulation of minds, kindling some into a blazing fire in the quest of distinctive achievement—is vastly different from the entrenched conservatism and the channelized operations of the "proper" scientific and engineering societies.

The older societies had their day. It was about a generation ago that Steinmetz and Edison and many others were philosophizing about the future of electrical engineering, when Karapetoff predicted that electromagnetic field phenomena and waves would be one of the most important areas of future investigation. The latter forecast, I might say, was to me, as a college student, utterly preposterous. Yet within 15 years I found myself writing a book based upon Maxwell's equations, electromagnetic waves, and all the things that Karapetoff said would be important, and teaching this very subject to college juniors and seniors.

Is it not possible that we are missing the boat? Couldn't we, in our colleges and universities and in meetings of the scientific and engineering societies, do a much more effective job of capturing the imaginations of youth and helping more of them on the road to significant discovery either in science or in new technology? Can't we break down the firmly entrenched bugaboos which restrict philosophical thinking about the future? Is it not possible to achieve that priceless quality so characteristic of the newer scientific societies—an open and challenging mind exploring the distant goals which science has in store—within the structure of the large well-established scientific and engineering societies?

This, it seems to me, is one of the crucial tests which will determine the pace of progress of our nation's scientific and technological advancement. When youthful seeds fall on sterile ground, when they are not nurtured in an environment of vision and encouragement and helpfulness, then that which comes forth is emaciated and underdeveloped.

"The old order changeth, yielding place to the new" is something we should never forget. That which is new and exciting today is destined to become commonplace tomorrow. The frontier will shift into something entirely new, not just an outgrowth of the old, but a leap ahead into something which could scarcely have been anticipated. The greatest problem that the technical societies have is to gear their operations to this changing scene of scientific–technological growth. It is not enough merely to adjust. They must vigorously pioneer the future if they are to fulfill their highest mission. Again and again the technical societies have failed to recognize this changing pattern and to lay the groundwork in their society operations to give full steam ahead to the distant goals—distant only in vision, for these goals materialize surprisingly fast. This is the reason why so many splinter societies have been formed in the past few years.

COMMUNICATION OF IDEAS

THERE ARE THOSE who decry the fact that fundamental research is not supported financially and that this is the cause of retardation. But the roots of the difficulties, I believe, are much deeper. This has been borne out by my observations as an adviser to one of the principal agencies of Government dealing with research. It soon became apparent that most of the proposals, even those in the fundamental sciences, although they had elements of originality, were well within the popular research clusters. It was a rare instance when an individual would come along who was trying to break through the sound barrier to achieve something in a new and relatively unexplored field.

No, the difficulty basically is not money. Its origins, I believe, are in the communication of ideas. It is the passing on of philosophical ideas and inspiration from

those who are immersed in the research frontiers and prolific with ideas to the young research individual who is groping in the dark, earnestly trying to find something different and important and promising to work on, but who will probably fall by the weight of gravity into a conventional field of research. If we could just find an effective link between these two, we could start far more of our young research people on the road to truly significant discovery. We don't have to worry about money; it will be forthcoming.

I believe that there is an awakening to this problem in some of the scientific and engineering societies. Some of them have ventured forth into experimental programs in which research individuals of eminence have been invited to explore the future philosophically. Often these have been the most exciting programs the societies have undertaken and they have been surprisingly well attended, mostly by young researchers who are searching for the new. Traditionally, scientists and engineers have shied away from prophecy in the public forum. Perhaps this is because prophecies do not always work out as anticipated. Furthermore, there is sometimes a feeling of futility, because there is no measure of achievement in such an endeavor. One never knows when he scores a hit in this kind of operation. Yet some young, eager, and enthusiastic individual, sitting in the third row at such a meeting, might seize upon an idea and go all the way, outdistancing even the prophecy.

One's achievements are limited by his area of significant contact. If that area is narrow and uninspiring and conventional, the accomplishments are correspondingly foreshortened. In research, the area must constantly be stretched, not only by enlarging the scope of knowledge, but more importantly, by philosophical explorations of the future.

Can we not provide within the structure of the scientific and engineering societies, a forum for vigorous discussion of the future—a forum in which people like Theodore Von Karmen, Ernest Lawrence, Vladimir Zworykin, Arthur Compton, and other eminent scientists and engineers would be invited to present their views on the future?

The American Society for Engineering Education (ASEE) and the National Science Foundation (NSF) several years ago started, at my suggestion, a joint program of Summer Institutes. Its purpose was to bring together scientists and educators, leading authorities in rapidly progressing fields which hold great promise for engineering of the future, to prepare recommendations as to how the new subject matter might be incorporated into engineering education. The meetings of the experts are followed by summer schools open to all who wish to attend. Nuclear science, solid-state physics, modern physics, thermodynamics, and advanced mathematics were subjects which have been very effectively developed in these Summer Institutes. These are primarily for teaching purposes. However, I believe that some such program as this might well be developed to bring able young research-minded people effectively into contact with leading research thinkers of our times.

ROLE OF COLLEGES AND UNIVERSITIES

THE COLLEGES AND UNIVERSITIES must also share in the responsibility of lifting the sights and goals of youth, for here is where the research patterns jell. There is much that the colleges can do to enlarge the visions of their graduate students and start more of them off on the road to significant achievement. But it takes faculty advisers of large vision to launch graduate students on this kind of research and, what is far more important, to help them come through to successful accomplishment.

Throughout history, progress in ideas has been made by genius breeding genius. Plato was a student of Socrates, and Aristotle a student of Plato. Again and again it has been proved that a great teacher can have a profound influence upon the course of development of a particular field.

In our society the channels are so often clogged up by traditions which inhibit genius from expressing its ideas philosophically. Isn't this stigmatism a major problem of our times?

Recently the Astronomy Division of the NSF completed a thoroughgoing study of the future of astronomical research. Such a study is not the last word—it never is—but it will be extremely helpful in giving clarity and direction to the future of astronomical research. Some of the engineering societies have undertaken similar studies of research fields, although, for the most part, these have confined their attentions largely to the well-established domains and have not leaped over these to go on to the distant goals of the newer sciences which hold great promise.

There are innumerable isolated cases of successful achievement by scientific and engineering societies in what might be called the philosophy of ideas. But we have never really come to grips head-on with the problem itself.

This is serious business. It affects the pace of progress of our whole emerging pattern of scientific and technological development. The scientific and engineering societies, along with the colleges and universities, share in a common obligation of studying this problem and finding ways of lifting the sights and the talents of our young people so that more of them will venture forth with a true pioneering research spirit.

A conference dealing with this subject, sponsored by the NSF, will be held at Worcester Polytechnic Institute this winter. Fifteen leading scientific and engineering societies, as well as the ASEE and the Engineering College Research Council, are co-operating in this conference. This conference will explore the question of what the scientific and engineering societies, as well as the colleges and universities, can do to bring our talented young people more stimulatively into contact with outstanding research people who can impart to them the perspective of fields of investigation which hold significant promise for original discovery.

Rapid Heating of Dielectric Materials at 915 Mc

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N. C. GITTINGER

THE HEATING of dielectric materials by means of microwave energy was investigated in the General Electric Company a decade ago by members of the Research Laboratory, who demonstrated the feasibility of preheating plastics and heating foods using a magnetron oscillator at a frequency of 1,000 mc (megacycles). In recent years, the *GL-6787* magnetron, operating in the 915-mc Industrial-Scientific-Medical band, has been developed as a source of power for these applications. In order to design equipment for efficient preheating, it is necessary to know the characteristics of the materials as a function of temperature. An initial investigation of the effectiveness of 915-mc heating on various dielectric materials has been conducted.

The power absorbed by a dielectric subjected to an alternating electric field can be calculated from the equation:

$$P = 0.555\, f\varepsilon'' E^2$$

where

P is the power absorbed, watts per cubic centimeter
f is the frequency in mc
E is the rms voltage gradient, kv per centimeter
ε'' is the loss factor of the material

The rate at which a material can be heated by dielectric heating depends on two factors:

1. The loss factor ε'' of the dielectric. This is the property of the material which gives the loss per unit volume for a given voltage gradient.
2. The frequency of operation.

The gradient E is usually limited by the breakdown of air between electrodes and the dielectric.

Since the loss factor is very low for many important dielectrics, the frequency of operation should be made as high as practicable in these applications. Because presently available dielectric heating apparatus operates at frequencies below 100 mc, the application of 915 mc makes it possible to heat some materials which previously could not be heated by this means.

Comparative tests of heating effectiveness were made at 915 mc and 70 mc, using a 3.5-kw commercial preheater. Samples were heated in both equipments under similar conditions, and from the results, the following conclusions were drawn:

1. If the loss factor of a material exceeded 0.01, the material could be heated at either frequency. The 915-mc equipment could heat it faster for a given voltage gradient, however.
2. If the loss factor of the material was between 0.01 and 0.001, the low-frequency heater heated the material very slowly. The 915-mc equipment could heat these materials at a relatively high rate.
3. If the loss factor of the material was below 0.001, neither equipment could heat it well.
4. In most cases, the limitation of heating in the lower frequency unit occurred because of arcing. At 915 mc, arcing rarely occurred at the powers used in the tests (100–600 watts).

Materials such as rubber styrene, Teflon *100X*, fluorothene, and styrene acrylonitrile could not be heated well at the lower frequency, but were heated easily at 915 mc. A special low-loss glass was also heated to the melting point at 915 mc, but could not be heated at the lower frequency.

A detailed investigation was made of the feasibility of rapid preheating of a general purpose phenolic compound, General Electric *12900*. The dielectric constant and power factor were found to be a function of temperature. As the phenolic heats up, there is a change in the impedance presented to the coaxial line by the cavity. Most of the change in the sample as it heats is in the dielectric constant, which tends to detune the cavity. The change in dielectric constant causes the power actually absorbed by the sample to change with temperature. Dynamic measurements were made of the power absorbed by the phenolic sample during a typical heating test. It was found that the input power varied considerably during the heating cycle.

The usual preheater operating in the vhf band consists of a self-resonant tank circuit in which the sample is placed. The frequency of operation adjusts to changes in capacitance caused by changes in the dielectric constant of the material. Because the magnetron oscillator has its own resonant circuit, the load cavity must be kept reasonably well matched in order to obtain rated output from the tube. During the experiments conducted with the phenolic samples, it was found that the resonant frequency of the heating cavity changed considerably with sample temperature, but the cavity impedance at resonance changed comparatively little. Heating of most of the samples was successfully accomplished by adjusting the cavity tuning while the samples heated up, with no change in the coupling of the cavity to the line. This fact suggested that a servo system designed to keep the resonant frequency of the cavity constant at all times would alleviate the matching problem. This servo system was built and successfully demonstrated.

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Measurement and Influence of Surface Charges in High-Voltage Phenomena

S. I. REYNOLDS

A discussion of the formation of the positive and negative charges left on the surface of insulation as a result of the electric discharge between a metal and a dielectric surface. Results of measurements with the rotating probe electrometer are given. This new method has opened up many experimental techniques for studying the influence of surface charges in high-voltage phenomena.

THE CHARGES left on the surface of solid insulating materials which have been subjected to an electric discharge were first discovered by Lichtenberg[1] when he observed the peculiar formation of resin dust on the surface of a resin sheet which had been exposed to discharges.

Many investigators since that time have studied charged surfaces by dusting techniques, by photographic plates exposed to the discharge, and by heat development of certain materials. They have shown by these methods that the extension and shape of the patterns are determined to some extent by the magnitude and polarity of the voltage transient. In addition, semiquantitative measurements have been made by induced charge techniques with a suitable electrometer.

In this report, results of measurements carried out by means of the rotating probe electrometer[2] are given which show the magnitude and polarity of charges existing on small areas of a dielectric after breakdown has occurred between dielectric and metal dielectric surfaces. Such results would be difficult to obtain using the other described methods.

With this new technique, charged areas as small as 0.3 cm^2 (square centimeter) in area and 1 mm (millimeter) apart can be measured at a rate fast enough to show changes within intervals of 30 milliseconds. The minimum detectable charge density is about 0.6×10^{-9} coulomb $cm.^{-2}$

Finally, the methods used for charge measurements at the exact voltage inception of a gap, the influence of these charges on the next breakdown, and its dependence on the polarity of the system are given.

THEORETICAL

THE ELECTRICAL STRENGTH of a gas enclosed between dielectric surfaces is approximately the same as between equally spaced metal electrodes.[3,4] Mason reports that the voltage inception V_i for voids in polyethylene is some 10 to 20% lower than the breakdown voltage in air between metal electrodes, and refers to previous reports which give even lower values for cellulose acetate and photographic plate surfaces.

It is believed that the shape of the positive and negative "Lichtenberg" figures formed on the surface of dielectrics,[5] when the applied potential is of sufficient magnitude to produce ionization, is caused by the greater mobility of electrons as they traverse paths in the gas adjacent to the dielectric surface. This brings about a deposition or removal of electrons from the surface which depends on the polarity of the applied voltage. When the polarity is negative, the bulk of the surface charge is supplied by emission from the metal cathode, and when positive, electrons are removed from the dielectric.

Once a dielectric surface becomes charged in this manner, the charges transferred at the initial polarity are trapped. When the polarity is reversed, the vector sum of the applied field and the reverse field resulting from these bound charges increases the field near the trapped charge and causes breakdown[6] at a lower value of V_i.

Mason[6] has shown that if the initial breakdown occurs just above the inception voltage V_i at one polarity, and if the polarity of the field is reversed, the breakdown voltage can then be reduced to values as low as 0.5 V_i.

Thomas[5] has shown that the charge left by an electric discharge of one polarity is not completely neutralized by a subsequent discharge of opposite polarity.

He concludes that when the discharge is negative, electrons penetrate into the surface and become so strongly bound that they cannot be easily reached by positive ions.

Gross[7] shows that the "homo" charge on electrets arises from discharges between electrodes and dielectric surfaces and states that when breakdowns occur at one point, the charge distribution of the dielectric at any other point remains unaffected if the surface charge is immobile.

PURPOSE OF MEASUREMENTS

THE FOREGOING theoretical discussion on breakdown voltage of a gas and its influence on charges produced on the surface of dielectrics as reported by a number of investigators suggests that the following experiments may lead to a better understanding of these phenomena.

A special article recommended by the AIEE Electrical Insulation Committee.

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The d-c inception voltage of a uniform field gap between a metal surface and a number of different dielectric surfaces will be determined by short-circuiting the gap electronically within a fraction of a microsecond of the discharge event.

The polarity, position, and magnitude of the surface charge obtained at the inception voltage will be determined by means of the rotating probe electrometer. Following these d-c tests, cycled a-c breakdowns will be made just above the inception voltage between dielectric surfaces with a uniform field gap to determine the polarity of charge on the opposite and adjacent dielectric surfaces in relation to the polarity of the last one-half voltage cycle.

MEASUREMENT OF SURFACE CHARGE

THE MAGNITUDE AND POLARITY of small charged areas formed on dielectric surfaces by a discharge can be measured by means of the rotating probe electrometer.[2] The measurement technique is described under apparatus and procedure.

The voltage induced on the probe as it passes over the surface at a distance of 1 mm is capacitively coupled to the input of a vacuum-tube electrometer, then amplified and presented on an oscilloscope where it can be calibrated and photographed.

From measurements of the input capacity to the electrometer C (with the probe connected) and the oscilloscope deflection for a measured peak-to-peak sine-wave voltage applied across this input capacity, the charge Q on the probe leading to an oscilloscope deflection d can be calculated. This is given by $Q = Cd/k$ where $k = d/V_e$, V_e being the peak-to-peak sine-wave voltage applied to C. If fringing is neglected, the charge density on the surface being scanned is given by $\sigma = Cd/Ak$ where A is the area of the probe (0.284×10^{-2} cm^2), and C is 189 μμf (micromicrofarads) and $k = 0.125 \times 10^{-4}$ cm per volt scope deflection.[2]

To measure the area on which the charge resides, marker pips are generated by placing two small wire electrodes embedded in polystyrene 3.48 mm apart and located in such a manner that the probe passes beneath the wires between passages over the areas being measured. By this means the polarity of the battery connected to the wires determines the polarity of the charge and the distance between pips is used to measure the charge diameter.

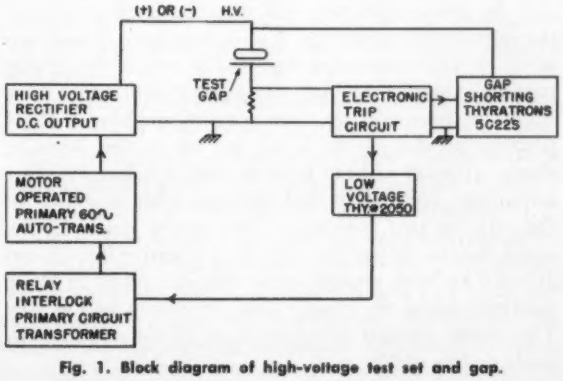

Fig. 1. Block diagram of high-voltage test set and gap.

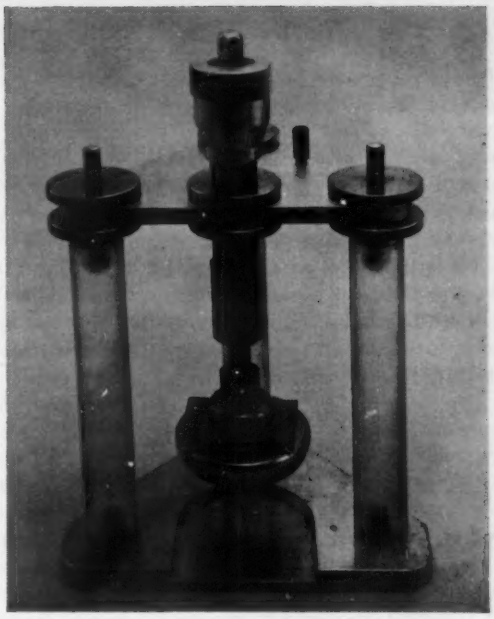

Fig. 2. Photo of test gap with dielectric surface plate.

APPARATUS AND PROCEDURE

IT WAS DECIDED to limit breakdown to the first discharge crossing the gap by short-circuiting the gap at the instant of inception. Then, if the resulting surface charge area remaining on the dielectric surface was smaller than the test electrode area and within the uniform field, one could be almost certain that the breakdown occurred at the inception voltage. With this in mind, an electronic circuit was developed. The first discharge across the gap is used to trigger a hydrogen thyratron which short-circuits the gap in parallel with it within a fraction of a microsecond. The remaining parts of the circuit open the primary circuit of the supply transformer, and operate a motor driven autotransformer to reduce the voltage to zero. A block diagram of the complete test circuit is shown in Fig. 1.

In order to maintain a uniform field gap for breakdown tests and to manipulate the dielectric sheets for surface charge measurements, the insulating material is fastened to the surface of flat 5×6-cm dural plates 1 mm thick, by means of double-coated pressure-sensitive tape (Minnesota Mining and Manufacturing Company's tape no. *666*). The insulation surface, in this manner is maintained flat in the uniform field gap facing the high-potential electrode as shown in Fig. 2 and also later placed on the slide manipulator by means of suction cups shown in Fig. 3 for scanning with the rotating probe. Charge location, polarity, and magnitude can

then be obtained by movement of the dielectric surfaces over the probe as it passes beneath the surface.

By this procedure, any detectable unwanted charge which might influence the applied field can be detected and removed before initial breakdown tests are made. After a discharge has occurred, the surface charge is then measured by photographing the trace which is presented on the oscilloscope screen synchronized with the rotating disk.

This technique of measurement has been found suitable for all of the dielectric materials tested, because the resulting bound charges remain fixed with no measurable change in area or magnitude during any of the tests reported in this article.

DISCHARGES AT THE INCEPTION VOLTAGE

A LARGE NUMBER of d-c breakdown tests were made between a 6.4-cm² circular stainless steel electrode and a number of different insulating materials at a gap distance of 1 mm with the high-voltage electrode negative and positive using the test gap shown in Fig. 2. The d-c voltage was increased at a rate of 400 volts per second, and the total applied voltage was recorded when the electronic circuit short-circuited the gap and cut off the supply voltage.

The sparking potential of the gap was then calculated using the a-c potential division equation[8] which takes into consideration the time constant of the system and assumes that the applied voltage V_0 is divided capacitively between the capacitance of the gap and the series capacitance of the dielectric as follows:

$$V_a = V_0\left(\frac{\tau_1 + \tau_2}{\tau\epsilon'} + 1\right)$$

where

V_a = sparking potential of the gap

τ = air gap setting in millimeters

τ_1 and τ_2 = thickness of the dielectric sheet and the sticker film respectively in millimeters

ϵ' = measured dielectric constant of the test sheet plus the sticker film

The observed values of the inception voltage V_a and the approximate charge area are listed in Table I.

Table I.

Dielectric Material	Inception Voltage V_a (kilovolts)	Charge Area (square centimeters)	Charge Polarity
Polychlorotrifluoroethylene	—4.5	0.79	(—)
Polychlorotrifluoroethylene	+4.65	4.2	(+)
Mica	—4.0	0.64	(—)
Mica	+4.4	1.54	(+)
Polyester resin	—4.6	0.64	(—)
Polyester resin	+4.6	1.54	(+)
Polyethylene	—4.5	0.95	(—)
Polyethylene	+4.6	1.86	(+)
Ethyl cellulose	—4.5	0.87	(—)
Metal Surfaces	±4.6	—	(±)

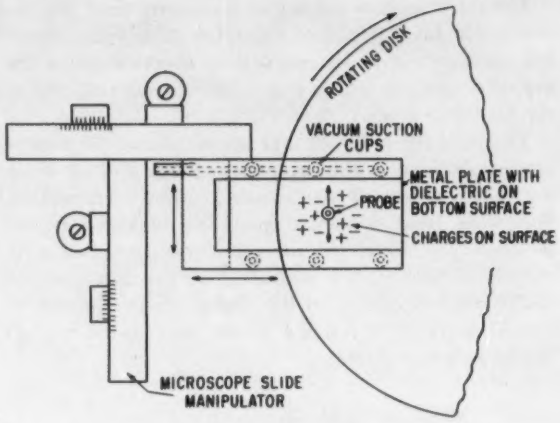

Fig. 3. Rotating probe scanning device.

SURFACE CHARGE EFFECT ON BREAKDOWN

IN ORDER TO DETERMINE the influence of positive and negative surface charges on the breakdown of a dielectric gap caused by the resulting enhanced field in the charged region, a series of tests were run starting with uncharged dielectric surfaces by measuring the inception voltage before and after field polarity reversal.

An example of results which are typical of many such tests repeated on insulating surfaces is illustrated as follows. After an initial breakdown at −4.6 kv to the surface of a polyethylene sample with the high-potential electrode negative, the surface was measured for charge position, polarity, and pulse height, and the CRO (cathode ray oscilloscope) trace was photographed. The surface charge pattern was then made visible by dusting the surface with lycopodium powder so that it could be photographed. The photograph of the charge pattern was then placed beside the CRO trace of the rotating probe as shown in Fig. 4A. The charged surface was then placed in the breakdown gap, and with the polarity reversed, the inception voltage occurred at (+ 2.3 kv). The resulting charge pattern and voltage trace shown in Fig. 4B indicate that the charge took place at the previous charged site and was responsible for reducing the inception voltage to 50% of the initial value, with the remaining surface charge still negative, showing that the positive discharge did not completely neutralize the initial negative charge. A second positive breakdown at + 3.6 kv is shown in Fig. 4C, in which the charge pattern extended beyond the original site with a very slight negative voltage trace remaining. After a third positive breakdown at + 4.2 kv, all of the negative charge appears to have been neutralized, but its effect on voltage breakdown still remains. This is shown in Fig. 4D for two positions of the probe voltage trace across the charge pattern. Finally, a negative breakdown at −3.6 kv with charge probe voltages taken at three positions across the charge area are shown in Fig. 4D. The charge pattern is the result of all the breakdowns made at this site.

CHARGE PATTERNS FROM A-C VOLTAGES

RESULTS OF THE D-C VOLTAGE TESTS show that the polarity of the charge on the dielectric surface opposite and facing the high-voltage electrode has the same polarity as the high-voltage electrode. One should then expect the charge on the dielectric surface opposite and facing the low-voltage electrode to have the same polarity as the low-voltage electrode. If voltage breakdown tests are made with a-c voltages between plane parallel dielectric surfaces, the polarity on the surface opposite the high-voltage electrode should have the same sign as the last one-half cycle and the charge on the other surface at the same site will be the unlike sign of the last half cycle, as shown in Fig. 5.

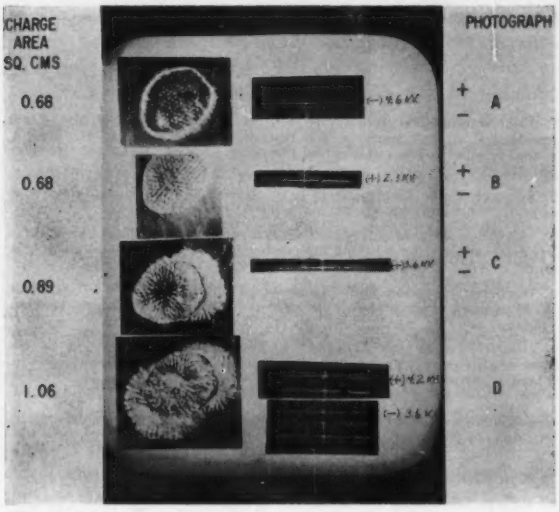

Fig. 4. Powder-developed charges and CRO traces of positive and negative discharge to polyethylene surface.

Consequently, a series of experiments was undertaken with 60-cycle voltages applied to dielectric surfaces separated by a 1 mm gap with the voltage just above the inception voltage for 1½ cycles. The voltage was triggered on and off at zero voltage with an electronically controlled vacuum switch in series with the high-potential winding of the supply transformer. The polarity of the last half cycle was determined by an oscilloscope connected across a capacitor divider in parallel with the test gap.

Test results from breakdown tests between polyester resin surfaces are shown in Fig. 6 which shows the charge measured by means of the probe electrometer at several different positions on both dielectric surfaces.

Photographs of the oscilloscope trace numbered 1, 2, 3, and 4 show negative charges measured with the probe on the polyester resin surface opposite to the low-voltage electrode which was negative on the last half cycle, and photographic traces of the polyester resin surface opposite the high-voltage electrode are shown in traces marked 5, 6, 7, and 8 located at the same positions and directly opposite to 1, 2, 3, and 4, respectively, to give positive charges on the surface with the same sign as the last half voltage cycle.

CHARGE MAGNITUDE OF SINGLE DISCHARGES

THOMAS HAS MEASURED the total amount of charge left on a dielectric surface using the lifted electrode technique of Gross. He found that the total charge from a negative breakdown to be about 9,100 μμc (micromicrocoulombs), at voltages above the inception voltage of a 0.5-mm gap and at rise times in the order of 0.4 microseconds, using a 7.9 cm² uniform field brass electrode; and total charge from positive wave front with same rise time to be about 6,200 μμc. He estimated that the central charged area had a negative charge of 7,000 μμc allowing 20% for the edge discharge.

By limiting the discharge, from a metal electrode across a 1-mm gap, to a dielectric surface in a uniform field to the inception voltage V_i, we have found, by virtue of the sharp resolution of the rotating probe, that the negative and positive charge areas are much smaller than the test electrode area and that their location is within the central uniform field area.

This sharp resolution requires that the total charge must be measured by making many passes of the probe at intervals of 2 mm from one edge of the charged surface to the other in order to obtain a total integrated charge of the whole area.

A typical charge voltage trace corresponding to a given charge density is shown in Figs. 4 and 6. The calibrated height of the voltage trace on the oscillograph for 1-volt deflection corresponds to a Ve value of 8 millivolts peak to peak of a sine wave across the input capacitance C of the electrometer. This corresponds to a Q value of 1.51×10^{-12} coulombs where $Q = CVe$.

Dividing this by the probe area of 0.284×10^{-2} cm², we obtain a charge density of 533×10^{-12} coulombs per cm² for 1-cm CRO deflection and calibrated at a probe distance of 1 mm. It has been determined that the width of the voltage trace at the points of inflection is within 8% of the true charge diameter. This width calibration is found by knowing the number of millimeters per division for the two market pips which the probe also sees as it passes over the charged area. By scanning the charged area in one direction at intervals of 2 mm, starting at zero deflection on one side to zero deflection on the other side of the charged area, the

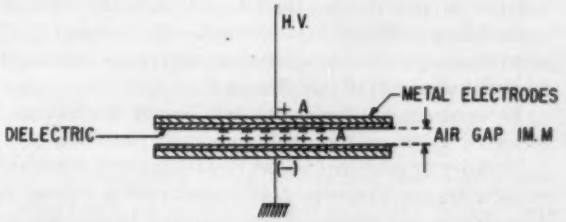

Fig. 5. Schematic of dielectric air gap and polarity of surface charges when high-voltage electrode is positive.

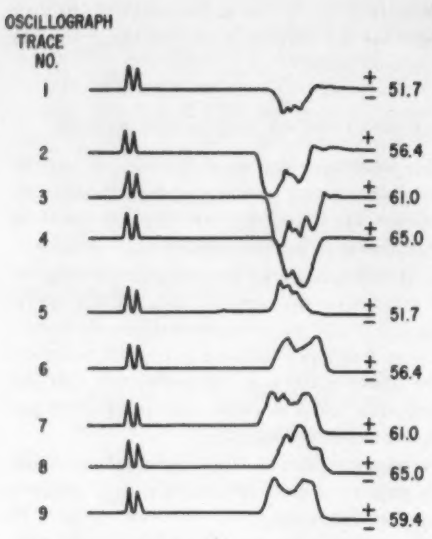

Fig. 6. CRO trace of charge patterns from 1½ a-c voltage cycles.

charge Q for each sweep can be determined. Then, by adding the different charges for each sweep of the probe, the total charge for a measured area can be integrated.

To determine the charge area for each sweep of the probe, let x equal the voltage deflection in μμc per volt; let y equal the charge width determined by the points of inflection as the probe passes over the charge area; then the μμc charge for each sweep is equal to 0.2 xy cm, where 0.2 cm is the width of the probe slice. A good analogy of this measurement is to consider that the total charge corresponds to a loaf of bread which is being sliced by a bread slicer until the whole loaf is sliced. Each slice is weighed, and the total weight corresponds to the total charge.

The total charge obtained from a negative and a positive charge remaining on a polyethylene surface obtained at the inception voltage of a 1 mm gap and measured with the rotating probe was measured to be 1,260 μμc for a + 4.6-kv positive breakdown and 1,300 μμc for a negative breakdown at - 4.7 kv.

CONCLUSIONS

THE INCEPTION VOLTAGE of a 1-mm gap in a uniform field between a metal electrode and a number of different insulating materials when the metal electrode is negative or positive has been found to be the same as the sparking potential between metal electrodes at 20 C and 760-mm pressure in agreement with results obtained by Dubsky[3] and Hall and Russek.[4]

The polarity of the charge left on the surface of a dielectric is the polarity of the opposite electrode.

Negative or positive charges remaining on the surface of dielectrics enhance the field if the applied polarity is opposite to the surface charge, causing breakdown to occur at a lower voltage than that of an uncharged surface. These findings are in agreement with Mason.[6] Neither positive nor negative charges are completely neutralized when a discharge takes place at the same discharge site when the field is reversed. This is in agreement with Thomas.[5]

The total negative charge obtained on a polyethylene surface from a single discharge at the inception voltage of a uniform field gap from a stainless steel electrode is 1,300 μμc and from a positive charge 1,260 μμc. Thomas[5] found a greater charge from a negative overvoltaged uniform field gap than from a positive breakdown. Unlike Thomas, it would appear that the negative and positive charges are essentially the same when the discharge is limited to the inception voltage in the uniform field.

It is hoped that this work can be continued with dielectric surfaces which have been subjected to ionization for extended periods of time and in the presence of different types of gases.

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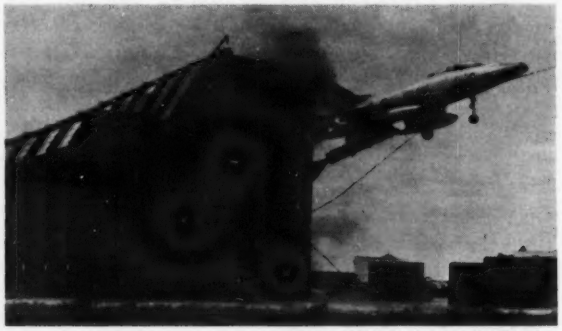
Sheltered Launch



Courtesy North American Aviation, Inc.

Proving a jet fighter can take off from a shelter designed to withstand an atomic blast, an Air Research and Development Command *F-100* Super Sabre completes a zero length launch (ZEL) at Holloman AFB, New Mexico.

Positive Feedback in Servosystems

Z. H. MEIKSIN
ASSOCIATE MEMBER AIEE

IN THE DESIGN of servosystems, two essentially opposing requirements have to be met: fast response and stability. Nonlinear and switching techniques provide new means to decrease the response time of a system without sacrificing stability. An accepted criteria for the evaluation of the response of a switching-type positioning servosystem is based on the time required by the system to settle to the steady state without overshoot, after a step input has been applied to the system. D. McDonald and J. B. Lewis described methods to improve the response time of servosystems by varying the damping coefficient of the system during the transient period. Another method, described by McDonald and A. M. Hopkin, is to reverse the forcing function of the system during the transient period. This method, although providing fast response, requires special measures to avoid erratic operation near the rest position.

A new method to shorten the response time of a positioning-type servosystem and to maintain the stability is to reverse the direction of the direct feedback during the transient period (i.e., to reverse the sign of the "spring" coefficient of the system). This may be visualized easiest by considering a second order system. The system starts to respond with positive feedback. The actuating signal is then equal to the sum of the input signal and the output signal of the system. As the systems start to respond, the actuating signal is increasing rather than decreasing as is the case for conventional negative feedback systems. This larger actuating signal provides proportional, increased acceleration of the system. To provide the required stability, the system switches into negative feedback operation at an instant established by a predetermined relationship between the error and the error rate of the system. Once the system operates with direct negative feedback, the actuating signal is given by the difference between the input signal and the output signal of the system, or the error, which reduces to zero when the system reaches the steady state. The negative feedback during the latter part of the transient period provides nonerratic operation near the rest position.

For relatively large input signals (in terms of the signal which causes saturation of the system) the positive feedback system may be driven into saturation for a large portion of the transient period before the system switches into negative feedback. This provides an economical design because the system is then utilized to its maximum capacity. A conventional negative feedback system with the same components would not be driven into saturation for the same input signal.

If the switching system is critically damped throughout the transient period, the response time is reduced to the order of 60% of the response time of the corresponding linear negative feedback system. The response is further improved if the system is less than critically damped during the positive feedback mode, and more than critically damped during the negative feedback mode. The response time may then be reduced to the order of 10%. Higher damping during the negative feedback mode of operation also provides a simple switching condition as described in the following paragraph.

The second order system is analyzed in the phase plane, which provides a description of the behavior of the system in terms of the error and the error rate of the system. This representation provides a straightforward means to determine the required switching conditions. The phase plane portrait is composed of curves, termed trajectories. For the more than critically damped negative feedback system, the portrait has two eigenvectors which are straight line trajectories. Switching from positive feedback to negative along the proper eigenvector secures fast response with no overshoot. The switching condition is then given by a simple linear relationship between the error and the error rate.

The third order system is analyzed in the phase space, which describes the system in terms of the error of the system and the first and second derivatives of the error. One switching action takes place when the system reaches a state which corresponds to any point on a surface, which is composed of positive feedback phase space trajectories, and includes a negative eigenvector. Another switching condition is again given by a relationship between the error and the error rate of the system as determined by one of three eigenvectors of the negative feedback trajectories. Higher order systems may be analyzed by the same technique.

Once the switching conditions are known, the system may be designed so that it will determine by itself the proper switching instant depending on a predetermined required relationship between the error of the system and the derivatives of the error.

This principle of operation may be extended to ramp and sectional linear input functions. The switching conditions and the mechanization of the system will, however, become more complicated.

In general, the more known about the possible input functions and initial conditions, and the more limited these conditions are, the simpler is the control mechanism of the system. The system proves most useful for step and jump (staircase) input functions.

Digest of paper 58-1301, "Positive Feedback Phase Space Trajectories and Application to Servo Systems," recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Pittsburgh, Pa., Oct. 26-31, 1958. Published in AIEE *Applications and Industry*, Jan. 1959.

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A High-Capacity Maintenance-Free Generating System for Motor Coaches

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High electric output and long life without maintenance are achieved in a recently developed generating system designed for use in motor coaches. It is expected that this system will also find application in marine engines, power shovels, and military equipment.

THE TREND of the electric loads on mobile equipment has been upward at an ever-increasing rate since the first generators were installed on automobiles in 1909. In the past, this load-trend curve has roughly followed that of the electric utility industry which doubles in load every 10 years, but the adoption of air-conditioning equipment in recent years has increased the connected load on automotive type equipment far beyond the value which would have been predicted by the load-trend curve. The growth of the electric load for coaches with 12-volt systems is illustrated in Fig. 1.

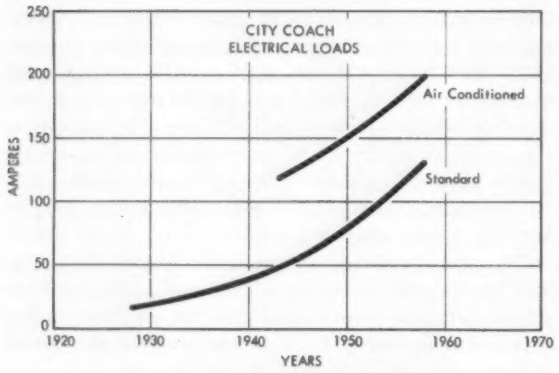

Fig. 1. Load-trend curve of motor coaches.

The capacity of the generator used to supply the load increased from 50 amperes in 1933 to 120 amperes in 1946, but even this striking increase in output does not indicate the relative capacities of the two generators, since the 120-ampere unit began supplying current to the load at 550 rpm, while the 50-ampere unit required a speed of 900 rpm to produce useful output. The speed at which the generator begins to supply current to the system became more important with the adoption of the hydraulic transmission, inasmuch as the normal pattern of operation in large cities is to operate the engine at full throttle for a period measured in seconds, then coast to the next stop.

Until this year, the standard generating system for most large-city coaches consisted of a 120-ampere d-c generator and double voltage and current regulators of the vibrating-contact type. The generator was gear driven at a 1.94 ratio and produced 80 amperes at engine idle speed. The field circuit was split into two halves, with each half regulated by a separate voltage and current regulator so that twice the normal field strength could be used without exceeding the maximum current rating of the regulator contacts.

Several things happened which determined that the d-c generator system was headed for obsolescence on large-city coaches. In addition to the rising load-trend curve heading toward a point where the electrical capacity and speed range of the largest conventional d-c generators would be inadequate, the diesel engines were being improved to the extent that engine overhauls were made less and less frequently. No longer would the generator and regulator operate satisfactorily without maintenance over the lengthened engine overhaul periods. In fact, the increased electric loads and the high engine compartment temperatures, which resulted from increased engine loads, contributed to the reduction in life of the brushes, oil seals, bearings, and other components from that which previously had been obtained. A-c generators with selenium rectifiers had been applied on some coaches with higher than normal electric loads but, although these generators would solve the electrical capacity problem for several years, the existing units had the same mechanical construction deficiencies as the d-c generator and, in addition, required the use of a large, expensive, and vulnerable selenium rectifier.

DESIGN OBJECTIVES

ABOUT 1955, the engineers at General Motors Truck and Coach Division began laying down specifications for the type of generating system which would be needed in the future. Because this generating system

Full text of paper 59-779, recommended by the AIEE Land Transportation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959.

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Acknowledgment is made of the contributions of the following people who were instrumental in the development of this system: R. H. Bertsche, R. O. Ellerby, E. E. Gegenheimer, and R. A. Carlson, of the General Motors Truck and Coach Division; and L. R. Hetzler, L. J. Sheldrake, and L. J. Raver, of the Delco-Remy Division, General Motors.

was expected to be one which would supply the needs of the coach operators for a number of years without any major revisions, the requirements set down were not met by any generating system in existence. A goal of 1 million miles of maintenance-free operation was set up to correspond to the expected life of the engine. The minimum generator capacity was set at 200 amperes, with 125 amperes output available at engine idle speed with provision to increase this output in the future with only minor revisions in the generator. The generator was to be of the a-c type with built-in silicon rectifiers and, in order to obtain the long-life operation desired, would have to be brushless and have permanently lubricated bearings. To prevent failures caused by the entry of dirt, detergents, and other foreign matter into the generator, or failures caused by lack of proper maintenance on air filters designed to prevent such damage, the generator was required to be environment-free. The regulator was required to be of a completely static design to eliminate all wearing parts and was to have the ability to retain its voltage setting unchanged over a period of years. In order that maximum performance could be obtained from a given size generator, the regulator was also required to supply much higher field power than had previously been thought practical.

GENERATOR DESIGN

A PHOTOGRAPH of the generator and regulator designed to meet the objectives specified is shown in Fig. 2 and a cutaway view of the generator is shown in Fig. 3. Basically, the machine is a 3-phase alternator with a 12-pole Lundell-type rotor. In order to obtain the brushless feature, however, several modifications have been made in the normal Lundell rotor construction. Two bearings are used on the drive end so that the entire rotor is supported from that end in an overhung fashion. A nonmagnetic ring has been added between the six poles of the drive-end rotor segment and the six poles of the outboard rotor segment so that the outboard segment is supported mechanically from the drive-end segment although the two are still isolated magnetically. An interior air gap has been added to separate the field coil and core assembly from the rotor poles, and the field coil and core assembly is supported from the end frame opposite the drive end.

In this manner, a rotating-field machine is made in which both the field winding and the output winding are stationary so that no brushes are required. There are several advantages of this type of design as compared to the other types of brushless generators that are known. A permanent-magnet generator could be used for an application such as this, but it is difficult to regulate the output voltage accurately without a considerable amount of bulky and expensive extra equipment; also, the field strength of such a generator is limited as compared to that obtainable in an excited-field machine. An inductor alternator would be another possibility, but this type of machine has an inherent 2-to-1 penalty in size and weight because the flux is pulsated from a maximum to a minimum value instead of being alternated between positive maximum and negative maximum values. A rotating rectifier type of machine could also be used but, in the size of generator considered here, an exciter is not needed to amplify the excitation power available from the regulator to a level sufficient to excite the main field. Consequently, the exciter becomes merely added weight, space, and expense, and serves no purpose other than to transfer the excitation power from the stationary member to the rotating member.

An additional advantage of the double air gap Lundell construction as compared to the normal Lundell construction arises from the separation of the rotating member from the field coil and core assembly. This reduces the moment of inertia of the rotor from 125 pound-inches^2 for a comparable size generator of standard Lundell construction to 96 pound-inches^2. This reduction in inertia is important since the generator-to-engine gear ratio is limited to a value which will not cause shaft and gear damage from the torsional vibrations of the diesel engine. Because of this reduction in inertia, it was possible to raise the gear ratio

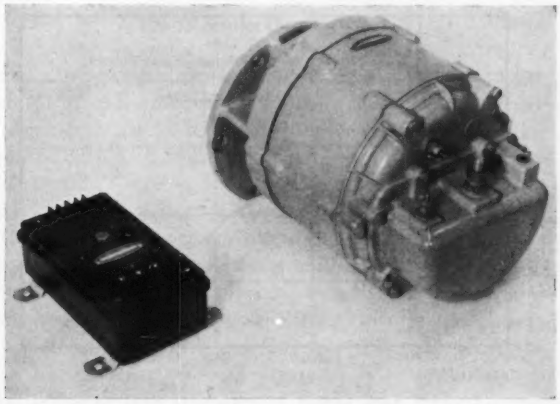


Fig. 2. Transistor regulator and oil-cooled generator.

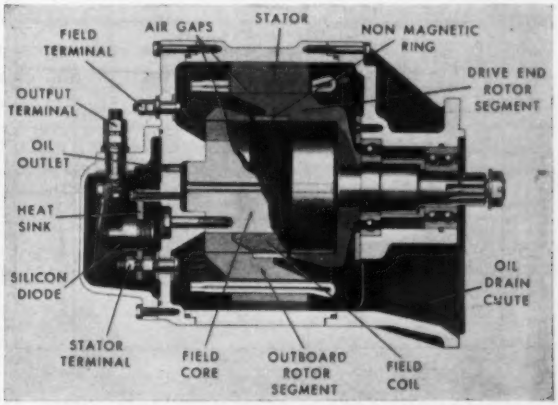


Fig. 3. Cutaway view of the oil-cooled generator.

from 1.94 to 2.29, and it would have been possible to raise the ratio even further had not the gear center distances available imposed a further restriction.

Rectifier Construction. The 3-phase full-wave bridge rectifier is made up of three silicon diodes mounted in the end frame and three silicon diodes mounted in small aluminum heat sinks, which are themselves supported from, and electrically common with, the three terminals of the stator winding which extend through the end frame.

Oil Cooling System. Several attempts were made to make the generator environment-free by utilizing totally enclosed or totally enclosed fan-cooled construction, but it was found that at the ambient temperatures prevailing in the engine compartment such a machine became too large and too heavy for consideration. Water cooling was also considered, but this involved the use of tubes and passages to conduct the water to and from the heat sources in the generator and was thought to be too expensive and too vulnerable to leaks to be considered. The only other cooling medium available on the engine was the engine oil. Since the oil is not electrically conductive, it can be thrown directly on the windings without fear of causing electrical failure and it has the added advantage of furnishing a permanent lubrication supply for the bearings. For these reasons, oil cooling was adopted for this generator.

The rectifier cover casting has provision to receive a fitting from an oil line which is connected to the engine oil gallery. There is a small orifice drilled in this casting which restricts the flow of oil to approximately 1 gallon per minute at the 40-psi regulated oil pressure which is available when the engine operates in its normal speed range. With the diodes entirely submerged in oil, excellent heat transfer is obtained so that large heat sinks are unnecessary. The oil fills the rectifier chamber to the level of the oil outlet. It then flows through the oil outlet and through the hole in the center of the field core. At the end of the field core, the oil is discharged against the inner surface of the rotor and is carried outward by centrifugal force to the inner air gap, through which it flows toward the rectifier end of the machine. Some of the oil escapes through slots between the nonmagnetic ring and the drive-end rotor segment and follows the underside of the poles outward until it is thrown off the poles onto the inside of the stator winding at the drive end. The rest of the oil continues toward the rectifier end of the machine until some of it escapes through the slots between the nonmagnetic ring and the outboard rotor segment and the remainder continues through the air gap to the end of the rotor where it is thrown on the inside of the stator winding at the rectifier end. Thus, the oil cools the stator winding by direct contact with the end windings and cools the field winding by conduction of heat through the core assembly and by direct contact with the field winding at the inner air gap. It then drains to the bottom of the stator assembly and, in the case of the oil at the rectifier end, flows through a notch between the stator laminations and the stator frame and drains down the chute in the drive-end frame to the flywheel housing of the engine. The oil level in the generator remains below the height of the air gap so that the rotor does not pick up the oil which has drained to the bottom of the stator.

The oil is taken from the engine after it has passed through the full-flow filter and the oil cooler in order that the cleanest and the coolest oil in the system will be used in the generator. Even under these conditions, however, the oil can at times reach an inlet temperature of 240 F, although the most normal operating range is around 200 F. The temperature of the oil increases about 50 F in passing through the generator under full-load conditions at high speed. One of the major problems to be solved in the development of the oil cooling system was the selection of insulation which would withstand the high-temperature oil bath. The insulation system being used consists of an epoxy coating on the magnet wire with glass tape on the field coil and isocyanate-impregnated glass slot insulation in the stator. All assemblies receive two coats of an oil-modified phenolic varnish which was selected after extensive

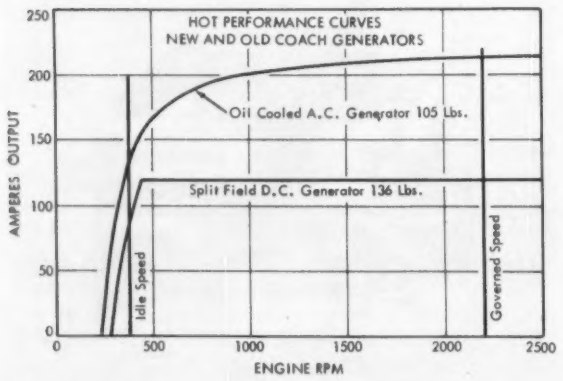


Fig. 4. Comparison of generator output curves.

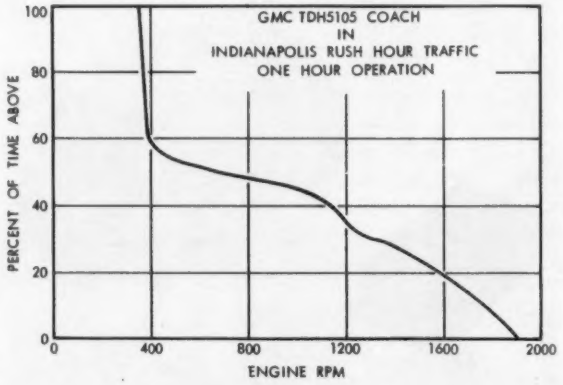


Fig. 5. Engine operating-speed characteristic.

testing of all available varnishes in a 300 F bath of used engine oil. The components used in the insulation system all have successfully withstood more than 12,000 hours in this bath. No difficulty has been experienced in operating units from insulation failures due to deterioration of the insulation.

When the oil cooling system was first proposed, it was thought that the generator would act as a centrifugal and magnetic oil filter and would soon be rendered inoperative by an accumulation of sludge. These fears have proved groundless.

Performance. A comparison between the performance of the new a-c generator system and the d-c generator system which it replaced is shown in Fig. 4. This illustrates the increase in output of approximately 75% throughout the speed range and the 23% reduction in weight which was obtained. Part of this increase in performance, of course, is the result of the 18% increase in gear ratio on the new system.

The importance of obtaining high generator output at engine idle speed becomes apparent if the curve of engine operating speed vs percentage of time shown in Fig. 5 is examined. This particular engine-speed curve was taken on a coach operating in downtown Indianapolis, Ind., during a normal afternoon rush hour, but it is representative of the conditions encountered in most medium-size cities. Surveys made of the operating conditions in metropolitan New York City and New Orleans, La., during the rush hour a few years ago indicated that the engine operated at idle speed as much as 70% of the time.

The engine operating speed characteristic can be combined with the generator performance curve, the generator drive ratio, and the battery characteristics to determine the amount of load which can be carried by the equipment in question on that particular driving schedule without producing a net charge or discharge of the battery. This value of system load is referred to as the "city load carrying capacity," which is frequently abbreviated as CLCC. In determining the CLCC, an assumption must be made as to the state of charge and the temperature of the battery since this determines the rate at which the battery will accept a charge. The battery temperature also determines the efficiency of the battery in ampere-hours of output as compared to the ampere-hours of input. The CLCC rating of a generator gives a much more accurate measure of its load-carrying ability under variable-speed driving conditions than does the maximum output rating. A comparison of the CLCC rating of the two coach generator systems with various battery conditions is given in Table I. The split-field generator calculations were made on the basis of a 14.5-volt regulator setting because that is a normal setting. The oil-cooled generator calculations are based upon a 14.0-volt setting because the battery can be kept charged with the lower setting when the higher capacity generator is used. The lower system voltage lengthens the life of lights and other electric equipment and reduces battery maintenance.

REGULATOR DESIGN

THE ONLY REGULATING UNIT that is necessary with this oil-cooled generator is a voltage regulator. No current regulator is required since the generator is inherently current limited, and no cutout relay is required since the silicon diodes effectively block any reverse current. The elimination of these two components from the regulator eliminates the need for heavy leads and large terminals to handle the output current and, consequently, reduces the size and weight of the regulator greatly. A comparison of the size and complexity of the transistor regulator used with the oil-cooled generator and the split-field regulator used with the d-c generator and the carbon-pile regulator used with the older style a-c generators is shown in Fig. 6. The comparison in size is even more striking when it is considered that the transistor regulator will handle two to three times as much field power and give much closer voltage regulation.

Circuit. The circuit of the transistor regulator is shown in Fig. 7 and the physical arrangement of the components on the printed circuit board is shown in Fig. 8. The voltage-divider network at the left side merely provides a means of adjusting the regulator voltage setting and of compensating for variations in the Zener voltage of the voltage reference diode. When the system voltage is higher than the regulator setting, the voltage reference diode will pass current, and this current flows in the emitter-base circuit of the driver transistor, turning it "on." In the "on" condition, the emitter-collector circuit of the driver transistor is essentially a short circuit which is connected across the emitter-base circuit of the two output transistors. This effectively short circuits any base current which would tend to flow in the output transistors and turns them "off." Since the output transistors are in series with the generator field winding, no field current can flow. With the field current turned off, the system voltage will fall until it reaches a value at which the voltage reference diode will no longer conduct current. Under those conditions, the diode blocks any current flow in the emitter-base circuit of the driver transistor and turns it off, thus removing the short circuit from the emitter-base circuit of the output transistors. Current will then flow through the emitter-base circuit of the output transistors and will turn them on so that field current can flow.

Table I. City Load-Carrying Capacity of Transit Coach Generators with Two 250-Ampere-Hour Batteries on Indianapolis Schedule

Generator	Gear Ratio	Voltage Regulator Setting	Battery Temperature, degrees F	Battery Per Cent Charge	CLCC
Split Field	1.9375	14.5	—10	60	88.7
Split Field	1.9375	14.5	—10	80	81.1
Split Field	1.9375	14.5	100	80	98.7
Oil Cooled	2.29	14.0	—10	80	124.1
Oil Cooled	2.29	14.0	100	80	163.5
Oil Cooled	2.29	14.0	100	100	**137.9**
Oil Cooled	1.9375	14.0	100	80	**142.0**

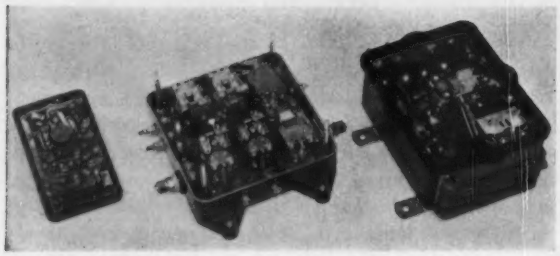


Fig. 6. Regulators used on motor coaches. *(Left)* Transistor voltage regulator. *(Center)* Split-field voltage and current regulator with cutout relay. *(Right)* Carbon-pile voltage regulator with cutout relay.

There are a few circuit refinements which aid the basic operation of the regulator as previously described. A silicon diode is connected between the positive line and the emitters of the output transistors so that field current flows through it in the forward direction. This is referred to as the back-bias diode. A high resistance back-bias bleed resistor is connected from the negative side of the diode to the negative line. The purpose of this combination is to prevent excessive leakage through the output transistors when they are in the "off" condition. The driver transistor is not a perfect short circuit in the "on" condition and would tend to allow a small amount of base current to flow in the output transistors, which would in turn allow a high leakage current to flow through the field. The drop across the driver transistor is approximately 0.3 volt in magnitude. By bleeding a small amount of current through the back-bias diode to develop its threshold voltage of approximately 0.5 volt, the voltage relationship at the output transistors is established with the bases being slightly more positive than the emitters. This biases the emitter junctions in the reverse direction and prevents any base current from flowing, thereby reducing the leakage current to a very low value. The nonlinear forward characteristic of the back-bias diode is used in place of the linear characteristic of a resistor to avoid dissipating a large amount of power in the regulator and reducing the power available for excitation of the field.

The feedback resistor is a low-value resistor which will have a voltage drop of approximately 0.1 volt across it when full field current is flowing. Its function is to cause the switching action of the regulator to occur very rapidly so that the output transistors are either in the "full on" or "full off" condition. It accomplishes this by subtracting a small increment of voltage from the voltage reference diode when the field current is turned on and adding a small increment of voltage to the voltage reference diode when the field current is turned off. This mode of operation is necessary so that the output transistors will go rapidly through the "partially on" condition, which is the condition of maximum heat dissipation. If the transistors were to operate by modulating the field current rather than by switching it, either the heat sinks provided would have to be of an excessively large size or the current rating of the unit would have to be reduced drastically. The feedback capacitor aids in securing this sharp switching action by transferring a voltage pulse from the output circuit back to the voltage-sensing circuit.

The field-discharge diode is connected so that it is in parallel with the generator field coil. When the generator field is turned off suddenly, a high voltage will be induced in the field winding if no path is provided to dissipate the energy stored in the magnetic field. This high voltage would puncture the output transistors. The field discharge diode provides a low impedance path through which the field current can circulate to discharge the stored energy but does not dissipate any power when the field current is on, since its leakage current is quite small. The time constant of the field winding with this low external resistance in series is high enough that the regulator does not switch in an extremely rapid manner as would be the case if a discharge resistor were used. Since the absence of light flicker in the coach is obtained with this regulator by the very small value of voltage excursion rather than by a high rate of switching, this low switching rate is desirable to limit the transistor heating.

The filter capacitor in the voltage-sensing network has the function of limiting the ripple which appears at the voltage reference diode. The action of the regulator is so fast that it would be actuated by each ripple peak on the voltage and would regulate at the peak value of the ripple instead of at the average value. This is not desirable since the magnitude of the ripple changes with load and frequency so that controlling the ripple peaks would result in variations of the average voltage of the system.

The switching action of the regulator is illustrated by the oscillograms of field voltage, field current, and terminal voltage in Fig. 9. It is readily apparent how the relative time duration of the "on" and "off" periods varies with the load on the system. Because of this action, the regulator is referred to as being of the pulse time controlled type. The temperature characteristics of the voltage reference diode and the driver transistor

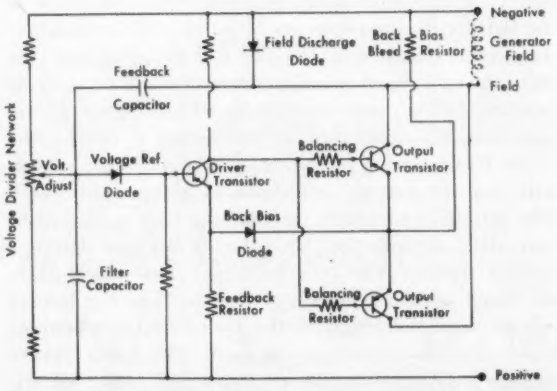


Fig. 7. Schematic circuit diagram of the transistor voltage regulator.

are approximately equal and opposite so that the regulated voltage does not vary appreciably with changes in ambient temperature. This is a desirable characteristic for a coach regulator. Because the regulator is mounted at a considerable distance from the battery, its temperature does not reflect battery temperature, for which many automotive regulators are compensated.

The ripple which appears on the field voltage and terminal voltage waves is 60 cycles, picked up by the oscillograph. When this ripple is eliminated, the terminal voltage excursions during switching are found to be about ± 0.1 volt and the variation in the average voltage with changes in load and generator speed does not exceed 0.4 volt over a temperature range of -20 F to 160 F. This represents much better voltage regulation than has been available on any automotive-type equipment in the past.

COACH CIRCUIT

THE GENERATOR AND REGULATOR described are markedly different from those which have been used in the past and consequently the application of these units to the coach brings up some problems that have not existed previously.

A d-c generator and a cutout relay are normally applied with the shunt field connected to the generator

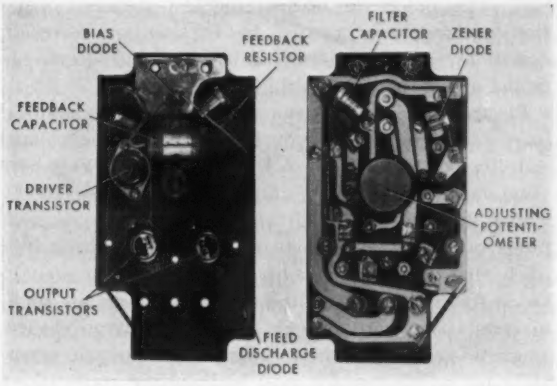


Fig. 8. View of both sides of printed circuit board assembly from the transistor voltage regulator.

side of the cutout relay. When the engine is started, the generator builds up enough voltage to close the cutout relay and begins to supply current to the system. When the engine is stopped, current from the battery will flow in a reverse direction through the cutout relay to drive the generator as a motor. This reverse current is used to open the relay and disconnect the generator from the system. With the a-c generator and the silicon rectifier, however, a cutout relay is not used. Since the field must be connected on the d-c side of the rectifier, there is nothing to prevent the battery from furnishing field current even when the engine is not in operation. In order to prevent discharge of the batteries by this

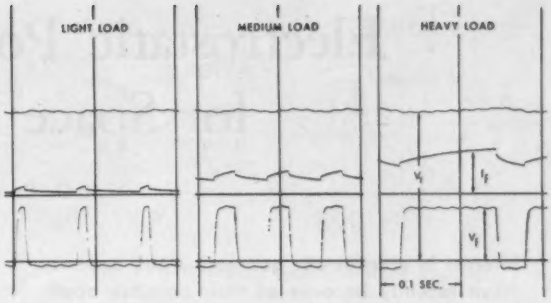


Fig. 9. Oscillograms of field voltage V_f, field current I_f, and terminal voltage V_t of oil-cooled generator with transistor regulator in operation.

field current, a field relay must be provided which disconnects the field from the battery when the engine is shut down. This relay is normally actuated from the ignition switch of a gasoline engine or from the "run" switch of the diesel engine.

The voltage appearing across the cutout relay contacts is frequently used to operate various interlock circuits on the coach, inasmuch as no voltage can appear at that point when the engine is operating, and the generating system is normal because the contacts will be closed. In order that interlock circuits can be actuated, one a-c terminal is brought out of the oil-cooled generator and a relay coil is connected between this terminal and ground. Thus, the relay coil is connected across one of the silicon diodes so that the pulsating reverse voltage appearing across the diode actuates the relay coil when the generator is in operation. When the engine is not in operation, the diodes in the opposite arm of the bridge block the battery voltage so that the relay coil is not energized. This relay in turn operates the interlock circuits through normally open or normally closed contacts, as desired.

CONCLUSIONS

THE ELECTRIC SYSTEM described has been developed primarily for operation on motor coaches, but there are many other types of heavy-duty applications where high electric output and long life without maintenance are required. It is felt that this environment-free generator and regulator combination will find application on marine engines, power shovels, and military equipment. The advantage of a generator having no wearing parts other than the continuously lubricated ball bearings and the advantage of a regulator which has no moving parts to wear out or change adjustments have been recognized by all operating personnel who have had contact with this system. Its reception has been most gratifying.

Experimental units have been on test since December 1956 and limited production has been under way since February 1958. The results of these operating units indicate that this approach is basically sound.

Electrostatic Power Generation for Space Propulsion

O. P. BREAUX

Interest in electrostatic generators has been revised recently because of their possible application in the field of space propulsion. Among their advantages for ion propulsion are ability to operate in a vacuum, generation of power at high voltages, and high efficiency.

THE FIRST TYPE of electric generator known was electrostatic. These generators were considered low-power machines with poor power-to-weight ratios, which was partly true for atmospheric and gravity conditions existing at the earth's surface. Under weightlessness and vacuum conditions, however, an electrostatic generator may have a power-to-mass ratio more favorable than that of electromagnetic equipment of equal output power.

Nuclear physics development requiring very high voltages led to the comeback of electrostatic generators. R. J. Van de Graaff in 1932 used the induction principle in a new way—the belt-type generator. Later operational difficulties in free air led to compressed-gas use. J. G. Trump developed the technique of belt machines under pressure at Massachusetts Institute of Technology and later at the High Voltage Engineering Corporation.

It was discovered that the small power of electrostatic generators operating at normal pressure in air was due to electric field limitations and resulting ionization of surrounding gas. Electrostatic energy depends on the electric field squared just as magnetic energy depends on the induction squared. In normal atmosphere, the electric field cannot exceed 30 kv per centimeter (cm), while it is comparatively easy to reach 10,000-gauss magnetic fields; magnetic fields are 10,000 times better than electric fields at normal atmosphere. If pressure is increased, the maximum permissible electrostatic field increases and a perfect electrostatic machine should supply a power 100 to 200 times larger by simple compression as compared to electrostatic power supplied at normal pressure. It was impossible to achieve this improvement with any of the older designs of electrostatic generators. Besides, older types supplied power too inefficiently to be of practical use in space vehicles.

A new type which has come into use is the cylindrical generator. The French company, S.A.M.E.S.,[1] has developed a complete line of electrostatic generators with cylinders rotating in hydrogen under pressure. This cylindrical form has no special advantage for very high voltages, but for large powers it is superior to other forms of moving parts such as belts because it may allow larger speeds without friction loss or damage.

The general form of dielectric-cylinder generators is represented in Fig. 1. The rotating dielectric cylinder, made of insulating resin and only a few millimeters thick, is similar in function to the belt of the Van de Graaff machine. The rotor rotates around a stator of slightly conductive glass, the air gap between stator and rotor being only 2 to 5 mm. Very thin steel strips replace the usual brush; they charge and discharge the rotor as a result of induction of metallic inductors which are concealed by the glass cylinder. Power of 1 watt per cm^2 is obtained by hydrogen at 15 to 20 atmospheres of pressure with an efficiency higher than 90%. This power can be achieved in permanent operation without wear caused by friction, or corrosion caused by sparks. Combinations which have been obtained are shown in Table I.

Electrostatic cylinder-type generators are economical for voltages above 20 or 30 kv where extreme voltage stability is required, for voltages above 100 kv where some stability is required, and for voltages above 100 kv where stabilities of 1.0% are sufficient. The present range of powers extends from 20 to 3,000 watts; it is likely that this range will be expanded to 6 or even 10 kw in the near future. Although their powers are small in comparison with powers supplied by large electromagnetic generators, the cylindrical electrostatic generators are satisfactory for most high-voltage applications and have advantages of extreme safety, excellent stability and regulation, and very small size.

The relatively new type of device for space electrostatic generation of power presently being considered is a single capacitor with the line voltage impressed across it, known as the variable-capacitance generator. With the rotor driven at synchronous speed, the unit delivers current to the line proportional to the voltage squared and the time rate of change of capacitance.

Table I. Characteristics of Dielectric-Cylinder Generators

Rotor Diameter, mm	Number of Poles	Voltage, kv	Current, ma	Power, kw
240	8	150	18	2.7
240	6	220	12	2.64
240	4	300	7	2.1
300	2	600	5	3.0

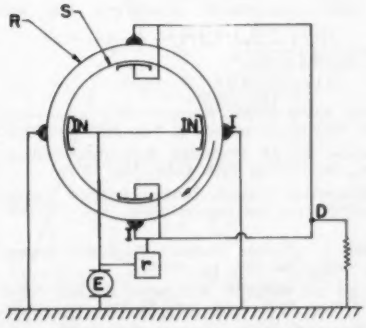
Full text of conference paper CP59-914, presented at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959, at a session sponsored by the AIEE Air Transportation Committee.

O. P. Breaux, 2nd Lt., U. S. Air Force, is with the Air Research and Development Command, Wright-Patterson Air Force Base, Ohio.

Rotating-plate electrostatic variable-capacitance machines possess some inherent advantages over electromagnetic units. Since space consists of very high vacuum, this may be employed as the dielectric, so that very little insulating material will be required. Relatively low weight-to-power and also low weight-to-size ratios can be realized. Bulky iron and copper coils required on conventional electromagnetic machines are eliminated; the electric field required by an electrostatic machine can be stored in the vacuum and requires only the presence of charge on the conducting surfaces. Because of elimination of windage, dielectric, hysteresis, and magnet losses and the reduction of ohmic losses through the reduction of the charging current required, the electrostatic variable-capacitance unit is more efficient. This efficiency reduces the demands on heat sink and radiators used for heat dissipation in space. J. G. Trump, experimenting with a rotating electrostatic generator, obtained an efficiency of 99% at full load.

The electrostatic variable-capacitance unit should be inherently more reliable than a comparable electromagnetic unit, as it can be of very simple all-metal design. The vacuum dielectric is not temperature-variant and does not possess the temperature-rise limitations of organic insulations. The electrostatic unit is capable of direct generation of high-voltage direct current required for some types of ion accelerators.

Present theoretical considerations indicate that the upper voltage gradient which can be tolerated in a vacuum is about 10^6 volts per cm at 100,000 volts; the upper limit for heavy particles will be about 100,000 volts. The current, at limiting voltage, will be limited by the time rate of charge of capacity which can be generated, or by the physical size and the rotational speed limitations of the device employed. Since the electrostatic generator is basically a current source, voltage regulation would be poor if widely varying loads were used, unless some type of compensation as feedback control were employed. Also, damping may have to be supplied externally, since there is no inherent damping in the electrostatic generator to suppress machine oscillations. The basic principle for variable-capacitance electrostatic power generation is shown in the following:



E—*Driving generator*
R—*Cylindrical dielectric rotor*
S—*Slightly conductive stator*
I—*Ionizer*
IN—*Inductor*
D—*Output electrode*
r—*Regulator*

Fig. 1. Schematic diagram of a cylindrical generator.

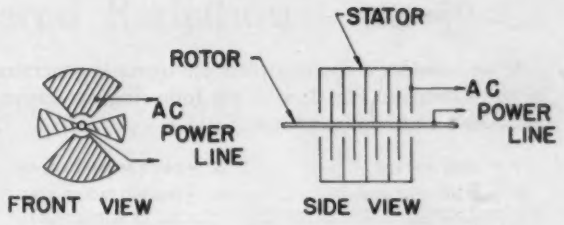


Fig. 2. Variable-capacitance electrostatic generator.

$$dW_{elec} = v\,dq = vi\,dt$$

$$c = q/v$$

where

dW_{elec} = change in electric energy of capacitor
v = voltage across capacitor
c = capacitance
q = charge
i = current

$$dq = i\,dt = c\,dv + v\,dc$$

$$dW_{elec} = v\,dq = v(c\,dv + v\,dc) = cv\,dv + v^2\,dc$$

$$W_{field} = 1/2\ cv^2$$

where

W_{field} = energy stored in field of capacitor

$$dW_{field} = cv\,dv + 1/2\ v^2\,dc$$

Now if assumption is made that energy can neither be created nor destroyed (law of conservation of energy), then

$$dW_{elec} = dW_{field} + dW_{mech}$$

where

dW_{mech} = change in mechanical energy

$$dW_{mech} = dW_{elec} - dW_{field}$$

$$dW_{mech} = (cv\,dv + v^2\,dc) - (cv\,dv + 1/2v^2\,dc)$$

or

$$dW_{mech} = 1/2\ v^2\,dc$$

In a report by the Rocketdyne Division of North American Aviation, Inc.,[2] a sinusoidal time change of capacitance is assumed.

$$c = C_{max} \sin^2 t = C_{max}\,\frac{1 - \cos 2t}{2}$$

also

$$v = V \sin (t + \phi)$$

now

$$\frac{dW_{mech}}{dt} = 1/2\ v^2\,\frac{dc}{dt} = \text{instantaneous power} = P_{inst}$$

and for the average power, considering its average over one cycle,

$$P_{avg} = \frac{V^2 C_{max}}{8} \sin 2\phi$$

If we consider a rotating-plate electrostatic generator as constructed in Fig. 2, with the following parameters associated with the generator:

V = peak voltage
p = number of poles
n = rotational speed
ϕ = phase angle
d = plate separation, cm
r_1 = outside radius, cm
r_2 = inside radius, cm
N = number of plates

then, by calculation of the capacitance in terms of the above parameters, and the given peak voltage and rotational speed,

$$P_{avg} = \frac{3.47 \times 10^{-14} V^2 np (r_1^2 - r_2^2)(N-1) \sin 2\phi}{d} \text{ watts}$$

Assume an output of 1 million watts and the following values for the parameters:

$n = \frac{40{,}000}{60}$ revolutions per second

$\phi = 45°$; $r_1 = 22.9$ cm; $p = 4$; $r_2 = 1.27$ cm

V_d = desired direct voltage after full-wave rectification = 100,000 volts

$d = 0.2$ cm

V = peak generation voltage = $\sqrt{2}\, V_d$

N was found equal to 337 plates. When consideration was given to the material of which the generator would be constructed, a practical value of 345 pounds was assumed. This resulted in a theoretical ratio of power to weight of approximately 2.9 kw per pound.

Large increases in power-to-weight ratios can be obtained for rotating-plate electrostatic generators if operating voltages for these devices can be increased. This is evident because the power of such a device is proportional to the square of the output voltage or to excitation voltage times output voltage. Thus, relatively small increases in voltage gradient will result in large power-to-weight ratios. Also, the average power drawn from the excitation voltage power supply is zero for the rotating-plate electrostatic device considered.

However, Rocketdyne indicates that some electrostatic devices require a voltage supply capable of supplying power for one half cycle and of receiving power for the other half cycle. High-voltage excitation sources capable of both supplying and receiving power should be investigated.

Thompson Ramo Wooldridge Inc. has been conducting a general parametric analysis to determine feasibility of electrostatic generators for advanced propulsion systems.[3] The analysis is based on examination of one a-c unit and one d-c unit of the variable-capacitance type. Preliminary results indicate that specific weight will be most favorable for high rotational speeds and high voltages. Increasing the number of poles reduces the specific weight until the increase in the pole number significantly affects capacitance variation.

Table II. Results of Analysis on Electrostatic Generators for Advanced Propulsion Systems

Material	Speed, rpm	Voltage, kv	Specific Weight, pounds per kw
Aluminum	2,000	30	100
	10,000	30	20.1
	2,000	100	75.3
	10,000	100	14.5
Stainless Steel	10,000	50	34.5
	40,000	50	8.4
	10,000	100	16.8
	40,000	100	4.2

Table II gives the results that are available from the analysis. The capacity of stainless steel to withstand greater stress—and, therefore, high speeds—makes it a superior material relative to aluminum for use in rotating-plate electrostatic generators.

A. J. Gale[3] has proposed a 100-kw 8-pole multiplate disk machine delivering 1 ampere. The machine would be driven at 10,000 rpm and would be approximately 15 inches in diameter and 10 inches in length. Its weight would be in the range of 20 to 40 pounds, giving a specific power density of from 2.5 to 5 kw per pound. Trump has suggested a 7,000-kw 500,000-volt d-c unit of the separately excited type. It would have 50 rotor blades and 16 poles, and would rotate at 4,000 rpm. The device would be about 6 feet in diameter and 10 feet long; no weight estimate has been given. A comparison of generators is shown in Table III.

Table III. Generator Comparison

Type	Specific Weight, pounds per kw	Optimum Current Range	Optimum Voltage Range
Electromagnetic Alternator	1.8–2.0	Intermediate	Intermediate
Electromagnetic D-C Generator	5	Intermediate	Intermediate
Electrostatic Generator	0.2–0.4	Very Low	Very High

CONCLUSION

THE ACTUAL POTENTIALITIES of vacuum-operating rotating-plate electrostatic generators have not been fully explored despite their inherent low losses and simplicity. These devices have several characteristics which are advantageous for ion propulsion: operation in a vacuum, generation of power at a high voltage, and high efficiency. Further development could make the vacuum electrostatic variable-capacitance generator competitive with electromagnetic machines for ion rocket systems.

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Control of Infrared Radiation

I. J. BARBER
MEMBER AIEE

IT HAS BEEN ESTABLISHED that the source of infrared radiation may be anything at a higher temperature than its surroundings, and that the quality and quantity of radiation by any such source is completely predictable and describable through well-known physical laws. The facts in this matter have been collected and summarized in a previously published paper.[1]

It is important to know how to design for the highest percentage of generated radiation which can be delivered to a desired area.

The contour of a reflector plays an important part in controlling the radiation initially developed by the source. A flat reflective surface is considerably better than a dark or missing oven wall, but generally it can be greatly improved by proper optical design. Reflective surfaces of materials of low specific reflectances substantially decrease the effective energy reaching the product. A reflector of a uniformly corrugated nature is less efficient than a corresponding flat reflector.

Many of the materials used, or proposed for use, as reflectors have been assigned reflectivities derived from theoretical considerations or limited scale tests. It appears from careful comparisons based on performance with specific sources that their specific reflectance to a 2,500-degree-Kelvin source is lower than projected. Some of the commonly used materials reappraised are anodized aluminums, aluminized steel, and electrically brightened and unbrightened aluminum. Specularity in a reflector material is an important quality, not so much from the standpoint of total reflectivity as from control.

While curved reflector contours are frequently used, it is sometimes desirable to duplicate their performance through the use of plane segments. These can be simply and effectively developed through the use of source images, as shown in Fig. 1. These segmented contours can be developed for any desired distribution of delivered energy, such as narrow lines, spots, etc., and for either linear or point sources. Where segmented plane reflectors are employed in multiple, the objective is usually uniformity in the combined radiant "field." Where the purpose is confinement into a narrow line or spot, the number of small segments required makes the reflector approach a regular curved form.

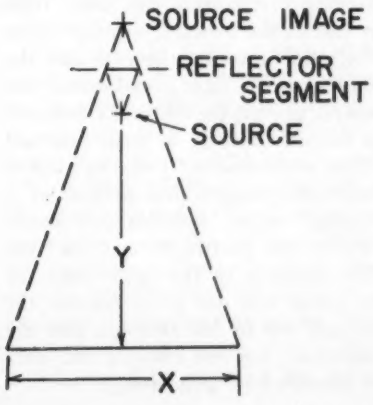

Fig. 1. Line from source image to limits of work area marks dimension of reflector segment.

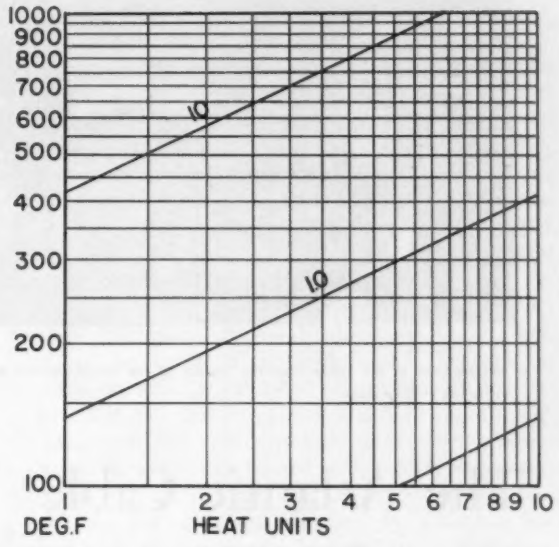

Fig. 2. Relationship between absorbed radiant energy and ultimate product temperature.

The over-all performance of a radiant oven is dependent on the optics and materials of the individual reflectors and the optical geometry of their multiple use. An oven built with maximum attention to efficiency of components and materials may be 10 to 15 times as effective as one of poor design in these particulars.

Relative comparative performances of radiant ovens may be approximately predicted through use of the theory of total radiation. Absorptances in heat units may be accurately related to ultimate product temperatures, as shown in Fig. 2.

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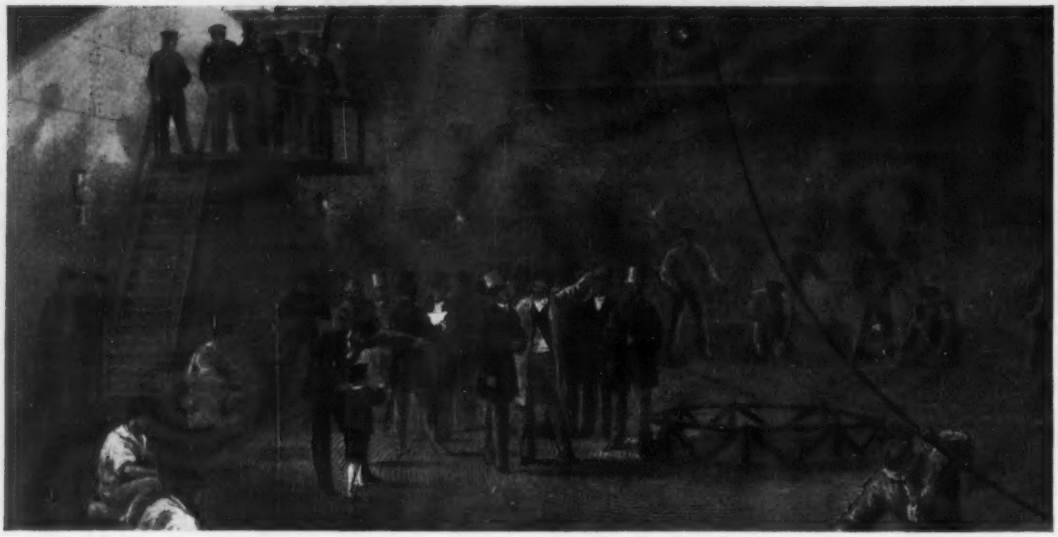

The transfer of the cable from the factory to the *Great Eastern* tanks was a long and exacting process. Here the Prince of Wales visits the coiling stage.

The Atlantic Cable
Part III

BERN DIBNER
FELLOW AIEE

This is the concluding installment of a three-part series on the laying of the Atlantic Cable.

THE PLACE for landing the cable had been changed from Valentia Harbor to a location 5 or 6 miles further to Foilhummerum Bay. Here the heavy cable was dragged from the deck of the *Caroline*, the ship carrying the heavier shore-end of the cable, across a pontoon of boats onto the beach and taken up the cliffs with the help and the shouted encouragement of the local people. Fastened on shore, the remainder of the cable was slowly uncoiled from the deck of the *Caroline* until the 30 miles of shore-end cable had been laid. Its water end was then fastened to a buoy in 75 fathoms of water. This was close to midnight and on the following morning the *Great Eastern* appeared with the ocean section of cable. The splice between this section and the shore section was immediately begun and satisfactorily finished by evening.

It was the early evening of Sunday, July 23rd, when the *Great Eastern* with her escort of two warships turned westward.

Shortly past midnight the boom of a gun, the signal of disaster, aroused the crew. There was a rush on board deck to learn what was wrong. Attention focussed on the electrical section, and there the electrician on duty had seen the light of his delicate galvanometer slide off the end of the scale and vanish. It was not a complete break, for a weak signal could be transmitted to the shore station. This signal gave notice that repairs would be undertaken, for a partial leak was indicated. The ship was 73 miles from shore and 84 miles of cable had been paid out. The electrical tests showed that the fault must be at a point 10 to 12 miles from the stern of the ship. It seemed necessary to recover the cable and cut out the defective section; there was nothing else to do.

In preparing for the necessity of picking up the cable at sea, machinery for such in-gathering was placed on the bow of the ship while the paying-out equipment was at the stern. This meant first cutting the cable, then transferring the cut end to the forward position across the long deck of the ship, inserting the end into the take-up machine and having the cable stored during the process. It was no simple matter, for the ship's deck was an eighth of a mile long, broken up by structures and equipment, with huge wheel-houses at the sides over which the cable had to be dragged. But difficult as it was, there was no other course, and this was finally done. Once gripped by the pulling-in machine, the ship moved eastward bringing in the cable from the ocean bottom. The strain was not great because the depth of water was only 400 to 500 fathoms. But the operation of the machinery was not efficient and after an hour only a mile of cable had been brought in.

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"The Atlantic Cable," book, published by Burndy Library, 1950.

It was not before Tuesday morning, and the gathering of over 10 miles of cable, that the cause of the trouble was brought on the deck. It was found that a small piece of iron wire, about the size of a needle, had pierced the insulation and touched the core. Although small, the penetration was deadly to the working of the cable.

The anger expressed by many did not help the wound; it was cut out and the good ends were spliced. A full day and a half had been lost as a result of this intrusion and it was not before Tuesday afternoon, July 25th, that the ship turned westward again.

Continual testing was carried on between the electricians on board ship and those at the Ireland station. Each hour was divided into four sections. The insulation was tested during the first half of the hour and the second half was devoted to the conductor characteristics by sub-dividing it into three 10-minute periods. Tests were made for conductor resistance and continuity. The tests clearly indicated an improvement in the insulation quality as the cable descended into the higher pressures of the ocean bottom and its lower temperatures. During the first half hour while the insulation was being tested, no attempts were made to communicate with the shore. The foregoing procedure, which prevailed during the 1865 expedition, was improved later.

After 4 days had rolled by, the trouble signal was again sounded and sudden anxiety again returned because the cable instruments indicated "full ground," but this time no signal passed through. It was again necessary to reverse the ship's course and retrieve the defective section of the cable from the ocean bottom. This was not an easy task since the defective section of cable now rested in 2 miles of ocean.

At 10 o'clock that night, the faulty section came aboard, was excised, and spliced. Another full day lost.

With the miles of cable that had been dragged from the ocean now lying about on deck, a careful inch-by-inch examination was begun on Monday, July 31st. Soon the fault became apparent. As in the previous fault, a pin was found driven through the insulation connecting the shield with the conductor core. This immediately cast suspicion on the crew especially when a similar instance was recalled wherein a nail had been driven in a deliberate act of sabotage through the insulation of a cable being laid across the North Sea.

This was not the last such set-back, where sharp pieces of wire short-circuited the insulation, but after several years' experience it became generally accepted as an unfortunate but unavoidable hazard, resulting from the unevenly brittle iron armor.

No further incidents marred the next 3 days when 500 additional miles of ocean were covered. All the machinery ran smoothly and even at its maximum depth, the dynamometer indicated no greater strain than 1,400 pounds. The electrical tests were constant and very satisfactory. The midpoint of the ocean had now been reached and, like going over a hill, it was felt that things should be easier for the rest of the journey. At the telegraph station on shore, it was noted by the electricians that the stability of the electrical system had become such that the very rolling of the *Great Eastern* was indicated on the sensitive galvanometer. This was explained by the fact that the moving cable, during such heaving and rolling, caused induced currents in the cable by the earth's magnetic field, which became visible on the instrument.

ANOTHER MISHAP

On Monday, they passed over the section of the ocean where, in June of 1858, three unsuccessful attempts had been made to lay cables from mid-ocean. Even this unfortunate area was now well behind them; they had successfully put down 1,200 miles of conductor and had only 600 miles to lay before reaching the welcome shore of Newfoundland. This meant that only 2 additional days separated them from the safer and shallower banks where all their troubles would be behind them. But events do not always conform to even the best laid plans. It was Wednesday, August 2nd. Field was on watch in the cable tank. The crew on duty was the same as had twice before brought trouble to the cable. Suddenly a grating sound was heard as if the machinery had enmeshed a piece of wire. A signal to be on the alert was flashed and quickly passed up the line, but not in time, for the faulty section had passed over the stern and into the sea. This was not enough to interrupt communication with Valentia but they were not notified before the order to cut the cable and to haul it aboard had been sounded.

Once again the cable was to be drawn aboard, but evidently not as much engineering talent had been spent on the hauling engine as that on the one to pay out the cable. The under-powered donkey engine pulled and puffed but the burden was too great. In the meantime, with the ship's motive power cut off, she began to drift over the cable and, such a large exposed side being less manageable, the cable became badly chafed. As the injured section was being hauled in over the bow, it suddenly broke and the sea end dropped into the water. This disaster came so unexpectedly and suddenly that there were few on deck to witness it. But the white faces of Canning and Field, who had neglected the luncheon table to stand by during the hauling operation, showed that they were in serious trouble. Canning staggered into the saloon announcing that it was all over! It was gone!

On board the *Great Eastern* a decision had to be made and Canning made it. He announced his intention of grappling for the cable, an experience never attempted at this great depth, here 2½ miles down. Such a contingency had not been anticipated, but 5 miles of wire rope had been stored for a possible situation in which the cable was to be lashed and tied to buoys, should it have to be so marked during a storm. The grapnels were quickly brought on deck. These were five-armed anchors especially designed for grappling. Their flukes were sharply curved and were tapered like a biting tooth. The giant grapples were shackled to the

In the electrician's room of the Great Eastern, a reply to a signal sent to Valentia is being awaited on Thomson's marine galvanometer.

iron ropes and lowered from the bow to fish for a million-dollar prize. It took 2 hours before their weights touched bottom.

The cable break had occurred shortly after noon so that, in a clear sun, observations taken had fairly well established the break point. The ship was now a dozen miles from this point which could be plotted within a half-mile certainty. After moving the ship a few miles eastward to miss the cable end, and a few miles south in order to cross perpendicularly to the cable, the ship slowly moved northward, beginning about 5 o'clock in the afternoon. All of that long night she crisscrossed the area where the cable lay on the ocean bed but it was not until morning that the long iron rope stiffened and quivered to indicate a load on the grapple, but with no indication as to what the grapple had caught. This uncertainty was dispelled by the dynamometer which showed an increasing strain as the take-in continued. Had it been some heavy loose object, the strain would have registered as decreasing as the grapple rose. The point of contact location also checked closely with that calculated by Capt. Anderson as that of the cable position.

As the cable rose, so rose the hopes of those on board the ship. When the grapple had risen three quarters of a mile an iron swivel failed and the cable returned to the ocean bottom, carrying nearly 2 miles of iron rope with it.

Three more attempts were made to raise the cable but each time the lifting wire rope was too weak for its burden. Insufficient gear remained for another trial after losing 2 miles of wire rope on the last attempt. There was nothing to do but to give up and return to home port.

THE EXPEDITION OF 1866

ANOTHER BATTLE had been lost, but in the eyes of the men on the bridge, the war was not only unfinished, it was certain to be won. The weeks spent at sea by the *Great Eastern* had clearly demonstrated the dependable elements of the expedition; they also showed the number of weaknesses that were still to be corrected. After discussing these points, those in charge of the expedition summarized their findings in a communication signed by William Thompson (Lord Kelvin); S. Canning, engineer-in-chief; James Anderson, captain of the *Great Eastern;* C. F. Varley, consulting electrician; and others who had officially taken part in the expedition aboard the *Great Eastern*. Quoting the report:

1. It was proved by the expedition of 1858, that a submarine telegraph cable could be laid between Ireland and Newfoundland, and messages transmitted through the same.

By the expedition of 1865 it has been fully demonstrated:

2. That the insulation of a cable improves very much after its submersion in the cold deep water of the Atlantic, and that its conducting power is considerably increased thereby.

3. That the steamship *Great Eastern,* from her size and constant steadiness, and from the control over her afforded by the joint use of paddles and screw, renders it safe to lay an Atlantic Cable in any weather.

4. That in a depth of over 2 miles, four attempts were made to grapple the cable. In three of them the cable was caught by the grapnel, and in the other the grapnel was fouled by the chain attached to it.

5. That the paying-out machinery used on board the *Great Eastern* worked perfectly, and can be confidently relied on for laying cables across the Atlantic.

6. That with the improved telegraphic instruments for long submarine lines, a speed of more than eight words per minute can be obtained through such a cable as the present Atlantic between Ireland and Newfoundland, as the amount of slack actually paid out did not exceed 14%, which would have made the total cable laid between Valentia and Heart's Content 1,900 miles.

7. That the present Atlantic Cable, though capable of bearing a strain of 7 tons, did not experience more than 1,400-weight in being paid out into the deepest water of the Atlantic between Ireland and Newfoundland.

8. That there is no difficulty in mooring buoys in the deep water of the Atlantic between Ireland and Newfoundland, and that two buoys even when moored by a piece of the Atlantic Cable itself, which had been previously lifted from the bottom, have ridden out a gale.

9. That more than 4 nautical miles of the Atlantic Cable have been recovered from a depth of over 2 miles, and that the insulation of the gutta-percha-covered wire was in no way whatever impaired by the depth of water or the strains to which it had been subjected by lifting and passing through the hauling-in apparatus.

10. That the cable of 1865, owing to the improvements introduced into the manufacture of the gutta-percha core, was more than 100 times better insulated than cables made in 1858, then considered perfect and still working.

11. That the electrical testing can be conducted with such unerring accuracy as to enable the electricians to discover the existence of a fault immediately after its production or development, and very quickly to ascertain its position in the cable.

12. That with a steam-engine attached to the paying-out machinery, should a fault be discovered on board whilst laying the cable, it is possible that it might be recovered before it had reached the bottom of the Atlantic, and repaired at once.

A new organization—the Anglo-American Telegraph Company, with a capital of £600,000, was formed The new company then contracted with the Atlantic Telegraph Company for the manufacture and laying of a cable in the summer of 1866.

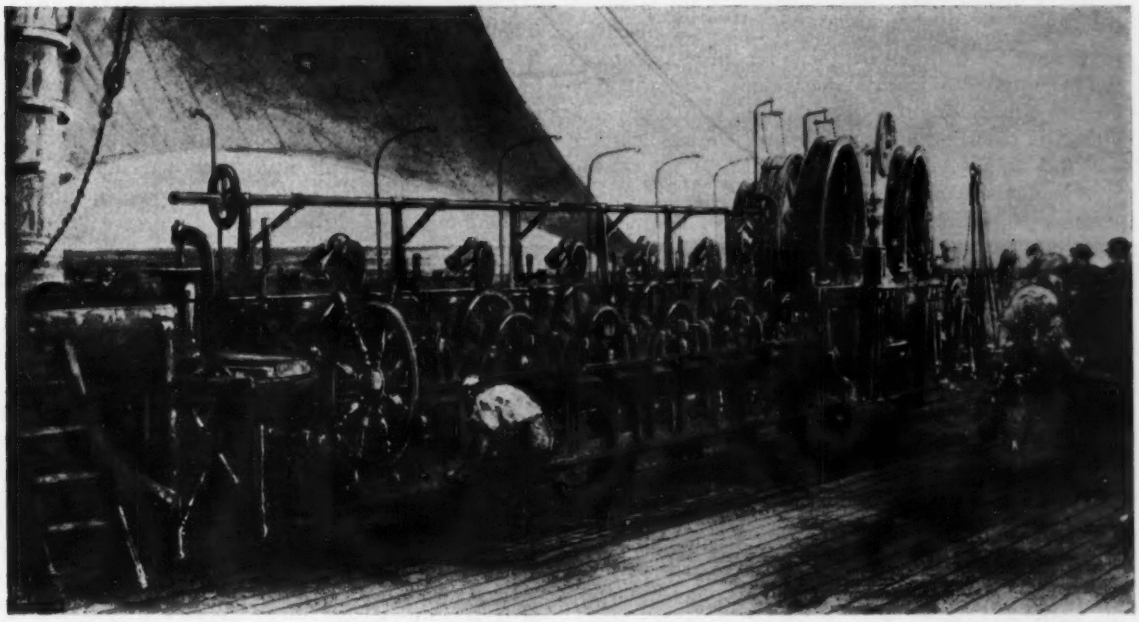
If the schedule of work were to assure the laying of the cable in the summer, then there were 1,660 nautical miles of cable to be fabricated in the 4 months ahead. The general cable design was retained but it was decided to galvanize the iron wires which would protect them from the salt water and extend their life. This also would replace the troublesome brittle protective covering of the previous cable. Instead of the black coating of the hemp saturant, the new cable had the bright outer appearance of the freshly galvanized zinc. This also reduced the possibility of small chips and wires adhering to the otherwise tarry surface. The resulting cable was lighter in weight by 400 pounds per mile and yet, because of the greater number of wires and galvanizing, its tensile strength was increased by a thousand pounds.

FINAL SUCCESS

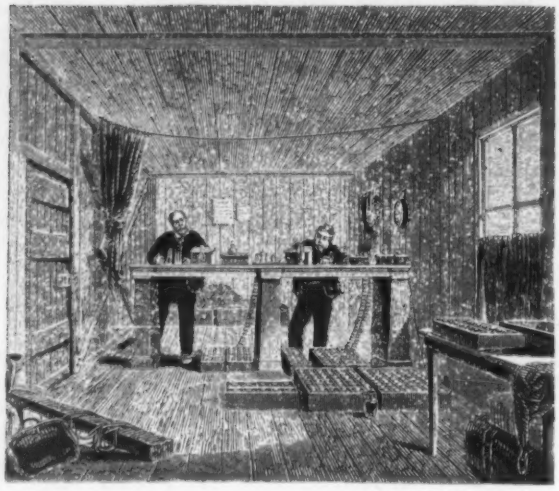
THE *Great Eastern* left her home port on June 30th, 1866, and moved on to Valentia where she awaited the laying of the heavier shore-end of cable that stretched 30 miles westward from the Irish coast. There the *Great Eastern* was joined by the *Albany* and the *Medway*, ships that were chartered by the company to escort the *Great Eastern*. The *Medway* was loaded with several hundred miles of the 1865 cable plus an additional, heavier length of 90 miles that was intended to be stretched across the mouth of the Gulf of St. Lawrence. Ready hands and a pontoon of boats helped bring the very heavy and stiff cable across the bay and up the cliff to the telegraph station. The 30 miles were then unrolled and the sea-end of the cable was buoyed in 100 fathoms of water.

The *Albany* sighted the buoy, and the cable end was hoisted and passed on over the stern of the *Great Eastern*. The interrupted signals on shore indicated that the splice was being made.

First, the copper conductors were joined, then the



Designed by Henry Clifford, the improved paying-out machinery used on the *Great Eastern* incorporated the automatic release mechanism and jockey wheels. The dynamometer is at the right. Equipment was located at the stern of the ship.



The primitive character of the telegraph cable outposts is shown by this instrument room at the eastern terminus, Foilhummerum, Valentia, Ireland.

insulation restored, and finally came the protective covering of galvanized shield wires. With this completed, the signalling was restored but the messages went eastward to the station at Valentia through the entire length of cable stored in the tanks of the *Great Eastern,* a total of 2,440 nautical miles. By 3 o'clock on that memorable July afternoon the paying out began as the ships moved westward in formation.

An average speed of about 5 knots was maintained over a continually quiet sea in rather good weather. Although concern for the unforeseen and an awareness of the previous failures were constantly in the minds of the executive personnel, still their reports and diaries were short in their entries, and repetitive, reflecting the monotony of smooth working under favorable conditions. The electrical tests continued with equal monotony to reflect optimum conditions. On the fifth day out, the sea was so calm that the masts of the convoy were seen reflected on the surface of the sea.

However, during the first half hour of Wednesday, July 18th, the only serious disturbance of the voyage occurred. It seems that in reeling out the cable from the after-tank, the cable fouled and some half-dozen turns became enmeshed. Fortunately, both ship and reeling machinery were quickly stopped. In the dark of the night and in a thick rain, with wind picking up, the crew set to untangling a seemingly hopeless jumble of cable stretching from tank to deck. It took 2 hours of constant searching and passing of parts of the cable forward and aft before some order was restored and the signal given to continue the paying operation.

Again the convoy passed the mid-ocean point which also was the graveyard of the cables of 1858. West of this, there rose a heavy wind and sea which again proved the strength and steadiness of the big ship. The blow did not last long and, in the subsequent calm, the evenness of the operation permitted the men's minds to turn to the constant flow of news maintained between the instrument room and the operators in the Valentia station. This constant signaling back and forth improved the technique and speed of the operators and maintained their confidence in their work. Although on the high seas, they were kept informed of parliamentary debates, the quotations of the London Stock Exchange and important events in England and abroad. Of the last there was plenty to report because a war had broken out between Austria, Prussia, and Italy in which battle followed battle. Like the reporting of the London Times, news bulletins were posted on deck twice daily. Important events were signaled to other members of the convoy, using flags by day and flash signals at night. In the meantime the cable continued to pass at the rate of 6 miles an hour.

On Monday, July 23rd, the deepest section of the course was traversed with no unexpected strain indicated by the dynamometer, which registered a maximum of 1,400 pounds.

On the 11th day out, the forward tank was beginning to empty and preparations were made to draw the cable from the tanks amidships. Only a few more days of sea travel remained and the thoughts of Cyrus Field looked ahead to the period of landing. He therefore requested Valentia to gather all of the latest news in Europe, Africa, and Asia so that it might be immediately put on the telegraph lines from Newfoundland to the Canadian and American systems. Otherwise the operation continued as described by Mr. Deane, "Cable going out merrily. Electrical tests and signals perfect, and this is the history of what has taken place from noon yesterday to noon to-day. May we have 3 days more of such delightful monotony!"

Even the fogs on the Newfoundland Banks were welcome, because this indicated shallower seas. Although the convoy was lost in the fog, contact was maintained by a system of whistles—two blasts from the *Terrible,* three from the *Medway,* and four from the *Albany,* each answered by one long blast from the mother ship.

As the western shore was approached, the signs that gladdened the heart of Columbus were equally welcome to the crews of the convoy. They were greeted by sea birds and floating things.

By 8 o'clock in the morning of Saturday, July 28th, the fog lifted and exposed both shores of Trinity Bay and the entrance of Heart's Content. The good news had preceded the arrival of the vessels because the community on the shore was in festive mood. British and American flags floated from such high points as the church steeple and the telegraph station. Again quoting Mr. Deane, "We had dressed ship, fired a salute, and given three cheers, and Captain Commerill of *HMS Terrible* was soon on board to congratulate us on our success. At 9 o'clock, ship's time, just as we had cut the cable and made arrangements for the *Medway* to lay the shore end, a message arrived giving us the concluding words of a leader in this morning's *Times:* 'It is a great work, a glory to our age and nation, and the men who have achieved it deserve to be honored among

the benefactors of their race'—'Treaty of peace signed between Prussia and Austria!' "

Preparations were made to splice the shore-end cable and Mr. Field had hurried ashore to engage a vessel to repair the break in the cable connecting Cape Ray, Newfoundland and Cape North, in Breton Island. Heart's Content was an inlet of the large bay known as Trinity Bay which is some 65 miles long and 20 miles broad. The village consisted of about 60 houses but it was chosen as the terminus of the Atlantic cable by Field because of its still, deep waters, favorable for cable laying.

The reception of the fleet did not compare with preparations made for earlier expeditions; there had been too many previous disappointments. However, those that did venture out were glad they were there to share in the unforgettable event. Field in his anxiety to get the many messages and items of news to the telegraph system was mortified to find that the cable crossing the Gulf of St. Lawrence, which had parted the year before, was still not fixed or replaced. This meant a 24-hour delay in getting through to New York. Field's instruction to the company in New York to repair the 10-year-old cable had been disregarded because they were not ready to spend any more money on the uncertain venture, unless it was absolutely necessary. A ship had to gap the communications break.

Again Field took the initiative, chartered a steamboat and had the broken cable lifted, spliced where it had been broken by an anchor, and then relaid. In the meantime Field's packet of news reached New York on Sunday morning instead of Friday, July 27th. The first message read:

> Heart's Content,
> July 27.
>
> We arrived here at nine o'clock this morning. All well. Thank God, the cable is laid, and is in perfect working order.
>
> CYRUS W. FIELD

This was followed by a dispatch to the Associated Press which described the voyage and ended with typical tribute to those who supported his effort. He said: "I cannot find words suitable to convey my admiration for the men who have so ably conducted the nautical, engineering, and electrical departments of this enterprise, amidst difficulties which must be seen to be appreciated. In fact, all on board of the telegraph fleet, and all connected with the enterprise, have done their best to have the cable made and laid in a perfect condition; and He who rules the winds and the waves has crowned their united efforts with perfect success."

This and other messages initiated a shower of congratulations and felicitations to Cyrus Field. Letters from sovereign heads, heads of state, and leaders of government, industry, and education poured in simultaneously. With a message from San Francisco, was one from M. de Lesseps from Alexandria, Egypt, where he had completed the Suez Canal. These electrically linked the most ancient kingdom in the east, with the most recently established large settlement in America's expanding West.

RETRIEVING THE LOST CABLE

THERE STILL REMAINED the task of retrieving the lost cable of the 1865 expedition. The *Albany* and *Terrible* steamed back to mid-ocean on August 1st, where they were joined a week later by the *Great Eastern*. Weeks of fruitless grappling ensued; rough weather hampered operations and time and again the cable would nearly be secured only to plunge again to the 2½-mile ocean depth. Finally, with supplies running out and the crews on half rations, a last attempt on August 31st was successful and the second cable was landed on September 7th.

THE TRIUMPH

DOUBLY CROWNED WITH SUCCESS, the Atlantic cable perpetually bound the Old World with the New. Many men gave more than a dozen years of their lives to this enterprise while others invested £2½ million ($12 million) to see this work successfully concluded. Field summed it up by saying: "It has been a long, hard struggle. Nearly 13 years of anxious watching and ceaseless toil. Often my heart has been ready to sink. Many times, when wandering in the forest of Newfoundland, in the pelting rain, or on the deck of ships, on dark, stormy nights—alone, far from home, I have almost accused myself of madness and folly to sacrifice the peace of my family, and all the hopes of life, for what might prove after all but a dream."

Slowly at first, but with increasing tempo, the value of the transatlantic telegraph became apparent daily. When Cyrus Field arrived at his desk every morning he found spread before him the noon quotations of the Royal Exchange in London. Only minutes now separated the two great capitals. It was now possible to telegraph from San Francisco eastwards to Ceylon, crossing three continents and two oceans.

The economic advantages of the telegraph were reflected in reduced inventories that merchants had to carry, because they were made more clearly aware of world market conditions by the quick exchange of information. Because of this awareness, traders could take advantage of lower prices in more abundant markets and thereby pass on these economies to wider circles of customers. Better knowledge replaced the speculation and hoarding that always went hand-in-hand with ignorance and uncertainty.

The rate of communication began with about eight words a minute transmitted by the operator. As the staff became better acquainted with the conditions of the line, the speed was increased to 15, 16, and 17 words a minute, an improvement helped by the installation of condensers added to the circuit. At $5 a word, the difference in transmission rate became very important in the economics of the service. A modern cable can handle a rate of 400 words a minute. At the time of Cyrus Field's death, no less than 10 cables spanned the Atlantic, carrying their ever-increasing load of messages.

Russian Visit to U. S. Computers

In April and May of 1959, an exchange of visits by computer experts took place between the United States and the USSR. This article describes the series of negotiations which led up to this exchange and the tour itself made by the Russian visitors.

Negotiations

M. M. ASTRAHAN
ASSOCIATE MEMBER AIEE

THE EXCHANGE had its beginning late in 1957 when a group of Russian scientists requested visas to attend the Eastern Joint Computer Conference in December of that year. The State Department asked the IRE (Institute of Radio Engineers) to make arrangements for an exchange under the assumption that a return invitation would be forthcoming. A United States group was selected quickly and alerted to the possibility of leaving in a hurry to visit Russia. However, there was not enough time left before the conference for such arrangements, no invitation was received, and the whole idea was dropped.

At a meeting in December, the National Joint Computer Committee (NJCC) reviewed the history of this proposed exchange. It was agreed that such an exchange would be desirable and that the NJCC was the proper agency to promote it. The NJCC voted to invite a Russian delegation to attend the 1958 Eastern Joint Computer Conference in Philadelphia, Pa., in December and also to visit United States computing installations and factories. In return an invitation would be expected for a United States delegation to visit similar installations in the Soviet Union. As NJCC chairman, I undertook to conduct the negotiations.

My first step was to contact the U.S. State Department. The person there most directly involved in the cultural exchange program is Miss Ellen Gavrisheff of the East-West Contacts staff. From Miss Gavrisheff I learned what every host of a Russian delegation should know. We would be responsible for making travel arrangements, securing a guide and interpreter, getting approval from the places to be visited, and watching out for closed areas. All arrangements are on a reciprocity basis, and the itinerary for each delegation must be agreed upon before the start of the exchange.

With the help of a State Department listing of some of the places we might wish to see in Russia, the NJCC Executive Committee drafted a letter to the USSR Academy of Sciences suggesting the exchange. This letter was sent in April 1958, and a follow-up was sent several months later, but no reply was received. Meanwhile, John Carr had succeeded in inviting four Russian scientists to attend the annual summer conference on digital computers at the University of Michigan. The Soviet group was in the United States from June 16 to June 30, lecturing at the University of Michigan as well as visiting several other universities and commercial installations. In August 1958, John Carr, Alan Perlis, James Robertson, and Norman Scott visited a number of computing centers and laboratories in the Soviet Union where they lectured on United States computer development. They discussed our exchange proposal with Academician Lebedev, who is the senior computer man in the USSR Academy of Sciences and director of the Institute for Precise Mechanics and Computational Techniques.

At John Carr's suggestion I cabled my invitation directly to the Academician Lebedev and followed it up with a registered letter. This occurred in October 1958. Within a week I received an answering wire which was the start of what has turned out to be quite an extensive correspondence by wire and letter. The wire was from A. V. Topchiev, vice-president of the USSR Academy of Sciences. Not only was it in Russian, but also the Russian characters had been transliterated into English, complete with transmission errors; thus, I had quite a problem getting this first wire translated. Fortunately, Miss Gavrisheff can translate mispronounced transliterated Russian by phone.

The first wire asked for information about the Eastern Joint Computer Conference and suggested that the Russians would like to see the NORC, TRANSAC, and IBM *704* and *709* machines. Nothing was said about a return invitation. With the assistance of Harry Goode, who is now chairman of the NJCC, I began to line up places to show the Russian delegation. As time passed, we had to forget the Eastern Joint Computer Conference in December and think only about visits to various places. Fourteen telegrams and four letters later, counting messages in each direction, we were ready to meet the Soviet delegation in New York. This counts only the overseas communications. The arrangements within this country consumed much more paper and telephone tolls. Much headache was saved by asking one person at each place to be visited to handle the tour organization, and one in each city to handle hotel arrangements. I would suggest that anyone considering organizing such an exchange should take full advantage of the experience now available. I will be happy to pass on this experience in more detail to any such person.

The Bendix Systems Division made E. M. Zaitzeff available to act as guide and interpreter for the group. He was selected because of his excellent command of Russian and his familiarity with computers. We met in New York on April 18, the day the Russians were ex-

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pected. However, they missed a connection in Amsterdam and all that we waiting for them knew was that they did not get on the plane; we had no way of knowing if they were still coming or not. Sunday morning, April 19, we got word that they were on the plane that day; Mr. Zaitzeff and I met them at the airport that night. We were accompanied by Prof. and Mrs. L. Bers. Prof. Bers, mathematician from New York University (NYU), as to be interpreter for our delegation to Russia.

The Visit

E. M. ZAITZEFF

ONLY SEVEN of the eight expected delegates arrived in New York. The eighth, Vsevolod Sergeevich Burtsev, whom I had an opportunity to meet a year ago at the Summer Computer Conference at the University of Michigan, was not among those who arrived. The members of the group were:

Sergeiy Alekseevich Lebedev, member of the Academy of Sciences of USSR, and the director of the Institute for Precise Mechanics and Computational Techniques. Academician Lebedev was involved in developing the MESM (small electronic computer) while in Kiev, and in developing and constructing the bigger Soviet computers BESM I (big electronic computer) and BESM II, which is to be put into production. Academician Lebedev was the official head of the group.

Dr. Vitaliy Arsenievich Ditkin, who is the assistant director of the Academy's Computing Center in Moscow. Dr. Ditkin heads a Mathematical Tables and Nomograms Group involved in calculation of tables by special functions. Dr. Ditkin also serves as the editor of *Vycheslitelnaja Matematika* (Computational Mathematics). Dr. Ditkin is a mathematician by education, and his interests are in operational calculations.

Yuriy Yakovlevich Bazilevskiy is an engineer and a member of the Committee of Radio Electronics. Mr. Bazilevskiy headed the design of STRELA I and III, and has supposedly worked on development of the URAL computer. His interests seemed to be quite broad, ranging from the design of computers and synthesis of automata, to the production techniques used in building of computers.

Sergeiy Nikitovich Mergelyan is a member of the Academy of Sciences of Armenia and corresponding member of the Academy of Sciences of USSR. He is a mathematician by education, and his interests lie in theory of functions, a subject about which he read lectures for 2 months in Italy at the University of Rome. At present, he is the director of the Institute of Electronic Computers in Erevan, Armenia. Three new computers are being developed at his Institute: EREVAN, which is a tube machine; ARAGATZ, which is also a tube machine; and RAZDAN, which is going to be the first fully transistorized Russian machine.

Viktor Mikhailovich Glushkov is a corresponding member of the Ukrainian Academy of Science, and a mathematician and physicist by education. His interests in mathematics were in group theory and other modern algebra subjects. He was also interested in machine learning and net synthesis. At present, Dr. Glushkov is the director of the Kiev Computing Center and a professor on the faculty of Kiev University.

Victor Semenovich Petrov is director of the Moscow Computer Factory. Most of the machines built there, according to Mr. Petrov, are the analog-type machines, but some digital machines are also being constructed. Very little information on his factory could be obtained from him.

Vladimir Stepanovich Polin is an engineer in the institute directed by Lebedev. His education was in molecular physics, but his present interests are in machine translation. His job is to work on a special machine design to be used for translation only.

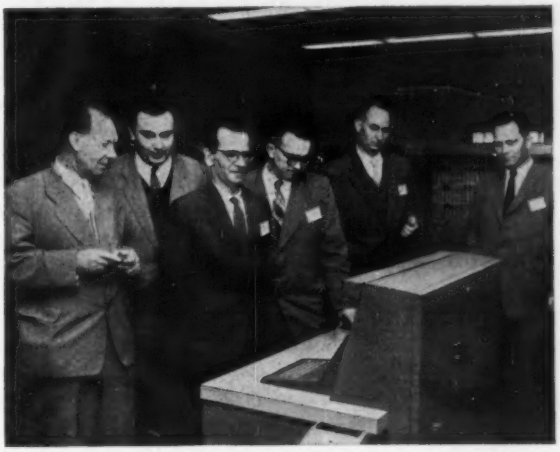


Fig. 1. At the 705 console in Poughkeepsie, N. Y. Left to right: Polin, Mergelyan, Lebedev, Glushkov, Bazilevskiy, Petrov.

IBM CORPORATION

AT IBM, the group was met by D. F. Ammerman, assistant general manager; Louis Voerman, manager of manufacturing; R. L. Palmer, manager of product development; Dr. F. P. Brooks, advisory engineer to the product development laboratory; T. B. Eschenbrenner, administrative assistant to the director of research, who came in from New York, and was responsible for the arranging of the group's stay at IBM. Also available to help in translation were T. B. Farrely, IBM field representative; and Wayne Kalenich, research librarian. Mr. Farrely studied Russian in school, and Mr. Kalenich, being Slav, had quite a good grasp of the language. After exchanging formalities in a conference room and introducing everyone, the group was taken on a tour of the main plant.

E. M. Zaitzeff is with the Bendix Systems Division, Ann Arbor, Mich.

The first stop of the plant tour was at the *705* installation where a number of group pictures were taken. These photographs were later given to the visiting group. From the *705* installation, the tour went to the third floor of the main building where a magnetic core matrix assembly was demonstrated. Many questions were asked in relation to this technique. Another point that interested the visitors was the programmed printed card component assembly machine which was operating at the time. The main *704* and *705* computer line was shown, including also a *7090*. A short stop at the transistor manufacturing room concluded the tour, and the group returned to the conference where a few questions were asked by both sides. Questions on the reliability of IBM computers were asked most often. Next in line were questions about the tape unit, tape interchangeability, and way of writing information on tape to insure reliability.

The next morning, Tuesday, April 21, the group was driven to the IBM Research Laboratories Building 701, where they were met by J. E. Fellows and escorted to the conference room. There, after greeting and orientation by Dr. L. P. Hunter and Dr. E. R. Piore, and exchange of formalities and presentation of the Russian books and papers which were brought by the group, the group was taken on a tour of the Magnetics Department Laboratories. The tour was conducted by E. W. Pugh. Questions on magnetic films and ways of depositing magnetic material onto films were asked. After the tour of the Magnetics Department and a coffee break in the cafeteria, the group was led to the Computing Center, where a *704* installation was examined. An experimental learning program for playing checkers was demonstrated, and Prof. Ditkin played against the machine. After a number of moves, the machine conceded. J. L. Ravesloot conducted the tour through the Computing Center.

A short lecture on machine learning was given by Dr. B. Dunham in the auditorium, and a number of questions concerning the subject were asked by Mr. Glushkov. After the lecture, the group was taken to the Semiconductor Research Laboratory, where Gunther-Mohr described the work done at that laboratory.

After luncheon in the conference dining room, a question and answer period began. Most of the questions asked by the Russian delegation dealt with the reliability of the machines, the tape units and their construction and operation, the preventive maintenance used on computers during the construction phase and also after installation in the field, and the time it takes to assemble different types of machines. More questions were asked on the details of manufacturing, as well as on the research conducted in the areas of new memories such as magnetic film, and cryogenics, and on the transistor research that is being done there, including some of the data on the later types of alloy junction and drift and diffused base transistors. In return, the members of the visiting group answered questions of the IBM people, which mostly dealt with the work being done in the USSR in the fields of machine learning, translation, weather prediction, as well as manufacturing of the machines. In machine learning it was stated that little work is being done, with the exception of some industrial processing learning computers. As far as the translation of language is concerned, the special purpose machine is believed to be the solution as far as the Russian scientists are concerned. At present, they are doing work on theoretical research of the languages to be translated, and to some extent, forming specifications for the special purpose machine to be built when sufficient background work has been done. Some work in establishing a system for abbreviation to be used in the translation machine is being done. This would decrease the necessary size of the memory. Also, ideas about the organization of such a machine are checked and tested. In the field of weather prediction, the group stated they have a special purpose machine called Pogoda (which means "weather" in English). They use this machine for long-term prediction for a month and short-term prediction for 24 hours. The monthly prediction is regular, the 24-hour prediction is less regular, on the average of two predictions a week being made. The data for prediction is taken from three layers and it takes about half an hour for the computer to run through the program. To the questions on how many points the data is taken from, Academician Lebedev stated that he did not know.

An additional plant tour of the production facilities was scheduled for the last Friday, as well as an afternoon question and answer period. The members of the group were quite pleased to hear that they would be allowed to return to IBM for another day, and assured Dr. Astrahan that they would do everything in their power to arrange for the American delegation to visit Erevan, a city not on the original schedule.

Massachusetts Institute of Technology

At Boston Airport to which they were next flown, we were met by Dr. Frank Verzuh and Mrs. Verzuh of MIT.

Early the next morning, at the MIT campus, Prof. P. M. Morse, director of the MIT Computational Center, started the day with a short presentation of the work done at MIT in the Compton Laboratories. Some questions by the visiting group about the structure of the organization at MIT Compton Laboratories were asked and a detailed block diagram was drawn for them on the board. Along with Prof. Morse and Dr. Verzuh, who is assistant director of the Computation Center, Prof. N. Arden, Prof. John McCarthy, and Dr. F. J. Corbato were present during the morning discussion. After the exchange of some of the printed material brought by the Russians and some of the paper handed out to the Russians by Dr. Verzuh, the group was taken to the IBM *704* installation, where a number of effective programs were demonstrated. M. L. Bullock of the IBM Corporation conducted the tour through the installation.

Lunch was served at the Faculty Club, where the group was joined by Prof. D. A. Buck and by D. T.

Ross. Also joining the group were B. M. Gurley and I. L. Levow from the Lincoln Laboratories staff. As the visiting group found out that Prof. Norbert Weiner was close in the building, they asked if it would be possible to see him. Especially interested in seeing him was Mr. Mergelyan, who had met Prof. Wiener previously in India during one of the conferences attended by both. Prof. Buck volunteered to locate Prof. Wiener. Mr. Mergelyan's English, which is quite good, allowed the two to converse about their present work without the need of the interpreter.

After lunch, Prof. Buck took the group to his Cryogenics Laboratory where an explanation of the work done there was given. Unfortunately, the containers for the liquid helium used for cooling the cryogenic materials were being refilled, and no actual demonstration could be given. Nevertheless, a very detailed and comprehensive explanation of the work was presented. The Russian group was quite interested in the way the helium is saved in operation in the laboratory, and were surprised to learn that this is not being done. Since helium is quite cheap in the United States, there is no necessity for saving it at the present time. On the other hand, in Russia, helium is not found in the natural state, and thus it is imperative that it be circulated without a large loss of the gas during the experiments.

From the Cryogenics Laboratory, the group was taken by D. T. Ross to the Servomechanisms Laboratory, where they were shown a computer-controlled milling machine and the work done by it. Some papers describing the work of the milling machine were passed out to the visitors.

The next stop on the tour was the *TX-0* computer installation on which a simple pattern recognition program was demonstrated. The program is a learning-type program which, during the course of experimenting, is supposed to improve its ability to decide between an *x* and a 0 drawn on a cathode ray tube face with a light pencil. The results of the experimenting by the visting group was satisfactory until the sizes of *x*'s and 0's decreased to the point where the machine seemed to guess randomly as to what figure was drawn. After close examination of the *TX-0* the group went to the conference room where the *TX-2* computer was described to the visitors. Unfortunately, they could not see the actual computer, but were shown some of the photographs and given the basic facts about it by the people from Lincoln Laboratories staff. The air-conditioning system of the Compton Laboratories was closely examined by the group, with special interest shown by Mr. Petrov and Mr. Bazilevskiy, who seemed to be interested in a variety of topics. Most of the questions asked that day were of the type asked at IBM, with some additional subjects touched. For instance, many questions were asked about the structure of the organization at the Compton Laboratories, the procedure that is taken in solution of the problems, how they are prepared and how they are solved, and how one obtains time on the machine. Also, some questions were asked on the translation activities at MIT, and the pattern recognition work done there.

The next day the group was taken to Harvard, where they were met by Prof. Aiken, Dr. Oettinger, and other members of the Computational Laboratory. The group was taken to the conference room, where a discussion ensued. Most of the discussion involved the structure of the Harvard Computational Laboratory. Later the group was taken upstairs where MARK I, MARK IV, and UNIVAC computers were shown. More discussions were held in individual offices.

PHILADELPHIA

AT THE PHILADELPHIA AIRPORT, the group was met by Morris Rubinoff of Philco Corporation and the Moore School of Engineering of the University of Pennsylvania. Dr. Rubinoff was to be the host for the stay in Philadelphia.

At 8:30 a.m. the next morning, Dr. Rubinoff and Henry Sparks from the University of Pennsylvania came to pick up the group and take them to the campus of the University. The group was led to the conference room, and greeted by representatives of the University of Pennsylvania, Burroughs, Radio Corporation of America (RCA), Leeds and Northrup, Philco, and Auerbach Electronics. The Russian group had stated their desire to see TRANSAC during their visit to the United States, but the facilities of Philco, where TRANSAC is being built, are restricted due to Government work. Therefore, the next best thing was done, namely a formal presentation on TRANSAC with colored slides, given by Mr. Rubinoff in the conference room of the Moore School of Electrical Engineering. This presentation took up most of the morning. After lunch, the conference was continued, with a description of RCA's *501* given by one of the representatives of that company, and many questions answered by the representatives of the other companies. Printed material about *S-2000* was handed out to the visitors.

The last part of the afternoon was taken up by the American members asking questions of the Russian group. In answer to the questions, the following facts were brought to light. The problem with skew in the tape units is quite acute. The tapes used in the units range from 6½ mm (millimeters) wide to 125 mm wide. Most common is the 35-mm tape which uses 10 channels. The tapes range up to 1 km (kilometer) long, but a lot of them are shorter than that. The average speed of the tape is between 2 and 4 meters per second. Most of the Russian machines are binary machines that do not have alphanumeric inputs. The reason, they state, is that all their machines are used for scientific problem solutions and very little data processing is done. Drums are used quite extensively and the majority of them are mounted on a horizontal axis, with 4 bits-per-millimeter packing density. They also state that the prices of their equipment are much lower than our prices. Comparing the drums for instance, they felt that a drum four times as large as the one described to them would cost one half the price of the American drum; thus, a factor of 8 is involved. This, they believe, is because no research time is charged to the drum purchaser. The printers

they described are operated up to 20 lines per second, which is equivalent to 1,200 lines per minute, which seems a little on the high side. These printers have a tolerance of 0.2 to 0.3 mm of up and down motion in lining up a line.

Other computers they touched upon were the VOLGA, which is a general purpose computer and not yet completed; POGODA, which is the weather prediction computer (special purpose); CRYSTAL, which is a special purpose machine for investigation of crystal structures; GRANIT, which is a special purpose machine for statistical investigations; the EREVAN, which is a tube machine and not yet completed; ARAGATZ, also a tube machine named after a mountain in Armenia (this machine is also not completed); and RAZDAN, a transistorized machine being developed and named after a river in Armenia. The last three computers are being designed with printed card circuitry and micro components, the construction being patterned after the type of IBM units where memory, arithmetic unit, and other large size units are separate from the main installation, and can be interchanged between installations. The *M* series machines, *M2* and *M3*, were also mentioned. No detailed information about any of these machines was given. In reply to a question about industrial processing control by computers, three types of systems were superficially described: a computer controlling the temperature and power of the melting of metals, a chemical process computer, and a computer installed on a train which considered the weight of the particular train, the profile of the terrain, and the time table it had to meet in computing the most efficient speeds at different points of the track. Some questions on the reliability of computers were raised, and the delegation asked if there were any figures on the difference of good time on computers, depending on whether the preventive maintenance was done or not. Figures were given on the UNIVAC at University of Pennsylvania, where it was stated that 95% good time was obtained with maintenance and only 88–91% good time obtained without maintenance.

NATIONAL BUREAU OF STANDARDS

MONDAY MORNING, April 27, the group was accompanied to the National Bureau of Standards (NBS) in Washington, D.C. by Capt. William Patterson, U. S. Army, temporarily attached to the State Department, who was assigned to assist me during the stay in Washington. They were met by Dr. S. N. Alexander and taken to the conference room of the Division of Applied Mathematics, where Deputy Director R. D. Huntoon gave a speech of welcome. The first part of the morning was directed by Miss Ida Rhodes, who speaks Russian, and who is connected with the Applied Mathematics Division, working on a machine translation of Russian into English. Most of the discussion dealt with the organization of the Division of Applied Mathematics of the NBS, and the types of problems that are being solved or worked on in that division. Questions of different approaches to solutions of problems were raised, as well as the size of the problems tackled.

The second part of the morning was spent in the Data Processing Division of the NBS with Dr. Alexander, the head of the division. Two programs were demonstrated on SEAC, one in data retrieval, which is to be used in finding chemical formulas to help in patent search, and the other a program of character recognition, which was demonstrated using Russian letters. After a close examination of SEAC, the visitors viewed a demonstration of an air traffic control system that is being developed at NBS.

BUREAU OF CENSUS

FOR LUNCH, the group went to the Bureau of Census, where a large UNIVAC installation was later shown, a model of FOSDIC explained, and samples of census cards passed out to the visitors. Many questions on the operation of FOSDIC were answered. In the evening, the group was asked by Jacob Rabinow to visit the Rabinow Engineering Company. Mr. Glushkov and Mr. Polin, Harry Goode, Sam Alexander, and I went to Rabinow Engineering. Since Mr. Rabinow speaks excellent Russian, no translation was necessary, and a lively conversation lasted until midnight between Mr. Rabinow and the visitors.

NORC

ON TUESDAY, April 28, the group was scheduled to go to Dahlgren, Va., where they were met by Capt. Utgoff of the U.S. Navy, who spoke to them in Russian. Reporters from two local newspapers were allowed to take some photographs, which were later distributed to the visitors, after which a tour of the computational facilities of the Proving Grounds was made. The group was split into two subgroups, one with me and the other with Capt. Patterson. The NORC installation was shown to the visitors, on which a number of experimental programs were run. A close inspection of CHARACTRON was allowed. Samples of the CHARACTRON prints were shown, and passed out to some of the visitors. Besides the actual NORC installation, the testing equipment for the packages and memory tubes were demonstrated. Also inspected were the generating facilities and cooling facilities for the installation. The repair shop and the data preparation room, using IBM equipment with card-to-tape converters, was shown. The final stop before lunch was to see the Automatic Data Translator that is being developed at the Proving Grounds.

FEDERAL AVIATION AGENCY

WEDNESDAY MORNING, April 29, the group was taken to the Federal Aviation Agency (FAA), where Commander LaLiberte, with Mr. Gruell, Mr. Fields, and Mr. Amberg, greeted the visitors. A formal presentation by Commander LaLiberte, with the help of Mr. Gruell and Mr. Fields, was given on the Federal Aviation Agency's air traffic control program. The presentation included graphs and slides, and a set of booklets and reports on the program were distributed to the visitors.

An additional discussion by Saul Amberg on the computer that is to be used in the program followed. A short question and answer period was held, during which the Russians stated that, unfortunately, they were not too familiar with traffic control, and no such program, so far as they knew, exists in their country.

PATENT DEPARTMENT

From the FAA, the group walked to the Bureau of Patents, where they were greeted by Robert Watson, commissioner of patents, and D. V. Andrews, director of research and development. After lunch in the building of the Bureau of Patents, the group went on a tour of the Patent Library, which was conducted by the Commissioner, and then was led to the conference room, where Mr. Andrews gave a formal presentation of the work in computational technology being conducted at the Bureau of Patents. Three approaches to the work were described. They included the punched card approach, the Ilas, and Ramac. After the description and a question and answer period, the Ramac installation was shown, with experimental program demonstrated. The other methods were offered to be shown, but were of no interest to the visitors.

IBM AGAIN

The next morning, May 1, Academician Lebedev, Mr. Bazilevskiy, and Mr. Petrov were taken to the IBM installation in Poughkeepsie, while Prof. Ditkin and Mr. Mergelyan were invited to give lectures at NYU. Mr. Polin and Mr. Glushkov remained in New York City to straighten out details of their return trip to Russia. The group was met at IBM by William Mair, general manager and vice-president of the company along with other personnel who were active in the previous visit of the Russian group to IBM. After a short discussion, the group was taken on a tour through the plant, where they were shown the pressing of the magnetic cores, the mixing of core powders, the firing ovens for the cores, and the automatic testing equipment for testing of the core parameters. They were given temperatures and other parameters of interest. Then the group was led to the magnetic head assembly section where they were shown the complete process starting from the individually stamped plates to the final assembly and polishing process. They were also conducted through the magnetic tape drive mechanisms assembly line and their testing set up. The group was given a demonstration of how magnetic memory matrices are checked by special equipment to determine whether the cores are all in proper position. Continuity checking of packages was shown, and individual package testing by hand methods on tube packages was demonstrated. The automatic programmed printed card assembly machine was shown again, but it was out of operation at the time, and each visitor received printed material on its description. Also received as souvenirs were small stamped plates from which the magnetic read and write heads are assembled, the paper forms on which the description of each individual core matrix memory is recorded, as well as the paper forms on which the history of tube packages are recorded. Since the group was much smaller this time, much better understanding of the operation of IBM facilities was possible, more questions could be asked and answered more thoroughly, and a more detailed observation of the process could be made.

After lunch, the group returned to the main plant, where the painting process used in painting the cabinets for IBM equipment was shown from the very beginning stage when paint is mixed, to the final stage when it is dried. A short discussion followed in the conference room after which the group started back toward New York.

GENERAL COMMENTS

In general, the group was quite co-operative and friendly with the interpreter. Most of them made comments about the friendliness of the American people with whom they had contact, and also stated that they did not expect as friendly a reception as they received.

Most of the members of the delegation, especially Prof. Ditkin and Academician Lebedev, repeatedly stated that this type of exchange is very good, and even if the political leaders of the countries might have some differences, they felt that the scientists should keep in contact with each other.

I can offer a few suggestions to the organizers of future exchanges. Probably the most important point is the need for sufficient interpreters for tours of factories and computer installations. One interpreter for four or five people is about the minimum relationship that can be advised. As for nontechnical activities such as checking into hotels, buying tickets at railroad stations, getting groups into cabs, and walking around stores, no more than four people should be with each interpreter. Realizing that this problem is not very easily solved, a compromise suggestion could be offered where at least an American with no knowledge of Russian could be assigned to the group besides an interpreter if the group consists of more than four or five people. Since almost all Russians that come for a visit in the United States have some knowledge of English, an additional individual who does not speak Russian could be of great help on occasions such as driving automobiles, checking into and out of hotels, taking care of bell hops and restaurant checks, as well as being able to take the group on tours of the city. In places where such help was available for the tour which has been described, it went much more smoothly than when only one individual acquainted with American customs and procedures was present.

Disregarding small troubles and problems that were all fairly satisfactorily resolved during the trip, the trip in general went off quite smoothly, mostly because of very good detailed organization of the program before the arrival of the visitors. When the program was well worked out by the individuals responsible for the group at each stop, it went off smoothly and enjoyably for both parties.

Abstracts of AIEE Technical Papers

COMMUNICATION DIVISION

59-153. More About Nonarmored Submarine Cable. *C. S. Lawton.* In 1953 a report was made on the manufacture and laying of a new type of deep-sea cable in which the conductor at the center also functioned as the strength member, thereby reducing bulk, weight, cost, and manufacturing time. This paper reports its recovery, stating that it was in excellent condition after 7 years on the ocean bottom at a depth of 1,250 fathoms, and offers the conclusion that expensive armor wire on the outside of cable for use in the greater depths generally is unnecessary. (C&E, Sept. 1959, pp. 367-69.)

GENERAL APPLICATIONS DIVISION

59-565. The Effect of Variable High-Altitude Humidity on the Wear of Nondusting Brushes. *L. E. Moberly, J. L. Johnson.* Erratic carbon brush wear which has sometimes been observed on actual high-altitude flights can be explained by the small variations which occur in the humidity of the atmosphere between 20,000 and 65,000 feet. Modern high-altitude brushes which have been specially prepared to prevent disastrous "dusting" wear still show a sensitivity to variable humidity even in this extremely dry range. The lower level of humidity which results in excessive brush wear varies from one type of brush to another. (A&I, Sept. 1959, pp. 263-67.)

59-654. Aluminum Bus for Shipboard Application. *G. J. Thompson, S. H. Behr.* Extensive laboratory tests over extended periods correlated with shipboard measurements on aluminum marine switchgear indicate that hard aluminum alloy, silver plated by a zincate process, can be joined and supported by the same methods as used for copper. The use of aluminum magnesium silicide alloy (55% IACS) provides more stable steel-bolted connections and greater resistance to deformation under high currents than the softer EC-H13 aluminum. The silver plating virtually eliminates joint assembly workmanship as a critical factor in assuring connection reliability. (A&I, Sept. 1959, pp. 239-47.)

INDUSTRY DIVISION

58-1057. Electrical Features of the Four Corners Pipe Line. *J. J. Sonnier, H. N. Siler.* This paper discusses generally the electric power distribution systems, control schemes, supervisory control, telemetering and communication means employed on a 650-mile-long 16-inch-diameter crude-oil pipe line completed in 1958. The stations are designed for complete unattended operation. The entire pipe line system, except for the feeder stations which are automatic, is remotely operated from the Terminal Office Building. A single-line diagram of power system, schematic drawings of supervisory control schemes, a pump unit control scheme, auxiliaries control schemes, and annunciator and miscellaneous schemes are detailed. (A&I, Sept. 1959, pp. 209-33.)

REFERENCES which accompany these abstracts are to the current bimonthly publications. Page numbers given will also apply to the corresponding part of AIEE *Transactions*, vol. 78, 1959, when it becomes available in the Spring of 1960.

Part I. Communication and Electronics (C&E)
Part II. Applications and Industry (A&I)
Part III. Power Apparatus and Systems (PA&S)

59-220. Notes on Bridged-T Complex Conjugate Compensation and 4-Terminal Network Loading. *Prapat Chandaket, A. B. Rosenstein.* A simple procedure is developed for the complete synthesis of the bridged-T network. The zeros of the network can be located at any point in the left half of the complex plane. Notch width, notch ratio, and notch location are simultaneously determined and controlled. A method is also developed to display the locus of the pole-zero change of the transfer function of any 4-terminal passive network with variable loading. It is shown how the loading effect can be used to advantage in the design of a bridged-T compensating network. (A&I, July 1959, pp. 148-63.)

INSTRUMENTATION DIVISION

59-159. Taut-Band Suspensions for 250-Degree Instruments. *V. S. Thomander, R. C. MacIndoe.* This line of instruments contain a moving element suspended by two high-tensile-strength metal bands assembled under tension, which replaces the conventional spiral springs, jewels, and pivot bearings. No friction can develop even under the most severe conditions of vibration, shock, or rough handling. Sensitivity, overload currents, and measuring-range limits are increased.

Because the suspension bands are taut, the element sag is small, permitting the instrument to be calibrated in any position with respect to gravity. Tests under all conceivable conditions, over a period of more than 2 years, have proven that these instruments will not "creep" or take a "set." Thus, they greatly reduce maintenance expense. (C&E, Sept. 1959, pp. 379-84.)

59-167. Statistical Approaches to Selecting Domestic Meters for Test. *Larry Dwon, J. A. Morris.* On the American Electric Power system, revenue watt-hour meters are selected for test once each 6 or 8 years. Past test results reveal that for every 100 meters tested, only four are found to be inaccurate beyond prescribed limits. This paper discusses the possibilities of statistical approaches to the selection of meters for test, their advantages and disadvantages and suggests how savings would accrue. (C&E, Sept. 1959, pp. 413-27.)

59-168. Polyphase Meter Connections 30 Years After Woodson. *F. W. Warburton.* In 1928 W. C. Woodson announced his procedure for verifying instrument transformer connections to meters for 3-phase 3-wire services. In 1928 the procedure had minor limitations. Since that time the employment of 3-phase 4-wire distribution systems, the growing impracticability of reducing customer loads for connection testing to balanced 3-phase known impedances, and the increasing use of capacitors have caused difficulty both in proving internal meter connections and in estimating the load phasors needed for comparison with the Woodson phasors obtained at the meter test switch. Today there is no procedure, Woodson or other, that will signal a definite "no" or "yes" that meter test switch phasors correspond to load phasors. Discussion and examples to substantiate these statements are given. Means for correcting part of the deficiencies are described. There remains the conclusion that a better method of connection proving is needed. (C&E, Sept. 1959, pp. 398-413.)

POWER DIVISION

58-1113. D-C Transmission: An American Viewpoint. *G. D. Breuer, M. M. Morack, L. W. Morton, C. A. Woodrow.* This paper includes a short history of d-c transmission, a description of d-c terminal apparatus and its operation, considerations of d-c line design as well as an economic comparison of a-c versus d-c transmission, and also consideration of the transportation of energy in the form of coal by rail. It was concluded that with the most optimistic expected costs for d-c terminal apparatus, a transmission distance of at least 400 miles would be necessary for d-c to break even with a-c. Further energy transportation in the form of coal by railroad was less costly than d-c transmission for all distances for the assumed conditions. (PA&S, Aug. 1959, pp. 504-15.)

58-1190. Protection of Pilot-Wire Relay Circuits. *AIEE Committee Report.* This report is concerned with pilot-wire circuits utilized in the 2-wire a-c protective relaying schemes where the requirements are more severe than other type services. Momentary trouble (1/60 second or more) in the pilot circuit can result in a major power interruption. The report discusses and summarizes the hazards encountered, outlines the protective devices available, and gives specific protection recommendations. These are applicable for the highly insulated or the low-voltage communication-type pilot-wire circuits, either privately owned or leased from the telephone companies. (PA&S, June 1959, pp. 205-15.)

59-2. Contribution to the Theory of the Brush-Collector Contact. *Else Holm.* An explanation is given for the common experience that, in the sliding contact of a carbon brush vs a copper collector ring, the contact voltage per brush is of the order of 1 volt. It is shown that about 1 volt is necessary for electrically breaking down or "fritting" the highly resistive collector film in order to produce and maintain current-carrying spots through the film during sliding (*a*-spots). Characteristic features of the fritting are demonstrated, including oscillograms of the voltage variation during frittings, and the determination of the produced conduction. This is carried out at various amounts of current *I* and mechanical load *P*, for stationary and sliding contacts. The observations prove that the *a*-spots produced by fritting assume sizes of only fractions of the load-bearing areas, are strongly dependent on *I*, but very little dependent on *P*. It becomes evident that in the wide range of *I* and *P*, the contact voltage remains close to the order of 1 volt. (PA&S, Aug. 1959, pp. 431-38.)

59-3. An Accurate Method of Calculation of Subtransient Reactances of Synchronous Machines. *K. B. Menon.* A rigid and accurate method of estimation of the subtransient reactances for the direct and quadrature axes of synchronous machines is presented. The field and damper winding magnetomotive forces are evaluated from the flux-density distribution curves and the rotor-circuit leakage permeances for the two axes. Equations for the subtransient reactances in the most general form are given. (PA&S, June 1959, pp. 371-79.)

59-25. Evaluation of the Internal Insulation of Generator Coils Based on Power-Factor Measurements. *D. A. Findlay, R. G. Brearley, C. C. Louttit.* Reliable evaluation of the internal insulation of generator coils is now possible using a test technique based on the increase in power factor from 4 to 8 kv and the coil's electrical position in the winding. The paper describes the successful application of this new approach to the coils removed from a 12-year-old 13.2-kv micafolium winding. This same technique applied to coils in stators reveals those damaged internally or those damaged externally by slot discharge, either condition requiring correction. For a periodic maintenance test, it is necessary to test only 10% of the total coils, being about one quarter of those operating above 5 kv to ground. (PA&S, June 1959, pp. 268-79.)

59-32. Rural Distribution Transformer Loading. *T. R. McDonald, D. B. Price, H. W. Thiesfeld.* Rural electric distribution systems present unique problems relative to economical transformer loading and sizing. This paper recognizes the extremely wide variation in individual farm load factor and discusses a promising method of predicting demand. A procedure is developed for applying the predicted demand in the determination of economical change-out time and optimum transformer size. (PA&S, June 1959, pp. 301-07.)

59-35. Equivalent Circuits for Overcurrent Calculations of Current Transformers. *E. E. Conner, T. R. Specht.* The purpose of this paper is to present an equivalent circuit for current transformers applicable over both the normal and overcurrent ranges of operation. In the normal range of operation where the core is not saturated, the proposed equivalent circuit reduces to the same circuit that has been derived by others and has been in successful use for years. In the overcurrent range, tests made on sample transformers showed good correlation with calculated results. (PA&S, June 1959, pp. 295-301.)

59-39. Measurement of End-Winding Leakage Reactance. *V. B. Honsinger.* A method of measuring end-winding leakage reactance, unsaturated-core reactance, and saturated-core reactance through measurements made on standard NEMA induction motors is explained. Core reactance is defined as the sum of slot and harmonic reactance. Data for 30 NEMA Design B motors is applied to a theoretical equation for end-winding leakage reactance derived in companion paper 59-40. Comparison of the theoretical equation with equations developed by Barnes, Gray, and Alger, and a general empirical correlation for random windings are given. (PA&S, Aug. 1959, pp. 426-31.)

59-40. Theory of End-Winding Leakage Reactance. *V. B. Honsinger.* An equation for end-winding leakage reactance is derived using Laplace's equation and techniques associated with 3-dimensional boundary value problems. Magnetic frames and bearing brackets are simulated by iron boundaries, and mutual effects with the rotor and coil shape and dimensions are considered. Various factors which influence inductance are separated and studied. A general equation covering all cases, an equation covering most cases, and an equation for die-cast squirrel-cage motors, which, in turn, is broken down into motors having V-shaped (formed coils), elliptical-shaped (random wound), and rectangular-shaped coils are given. (PA&S, Aug. 1959, pp. 417-26.)

59-41. The X/R Method of Applying Power Circuit Breakers. *J. E. Skuderna.* A new method for rating power circuit breakers was presented at the January 1954 AIEE Winter General Meeting, in which it was proposed that the various characteristics of a breaker be combined into one rating called rated short-circuit current. To compare these characteristics with actual fault duties, this paper develops a method which is intended to be used as a simplified application procedure for breakers rated on the proposed new basis. (PA&S, June 1959, pp. 328-38.)

59-42. Large Metropolitan Distribution Substations. *T. D. Reimers.* Until the development of 1,000-mva 13.8-kv magnetic air breakers in 1958, large substations of about 200 mva capacity supplying feeders to 4-kv network or low-voltage network banks used air-blast breakers and phase-isolated metal-clad bus installed in a building. The use of the 1,000-mva magnetic air breakers in outdoor housings with covered working aisles has materially decreased the installed cost of these large distribution stations. But arrangement provides minimum voltage and phase-angle variation between feeders. Reliability is obtained by physically spacing and isolating major components. Simplified control and flexible ground and test facilities are features. (PA&S, June 1959, pp. 395-401).

59-45. Stray-Load Losses in Polyphase Induction Machines. *P. L. Alger, G. Angst, E. J. Davies.* This paper presents approximate equations for the stray-load losses in induction machines, together with some comparisons between test and calculated values. The stray losses are the excess of the total losses actually occurring at a given load current over the sum of the no-load losses and the calculated I^2R losses for that current. Dimensionally correct formulas are given for each of the six major components of the loss, and it is shown that the numerical values of the total agree reasonably well with tests over a wide range of motor size and speed, for both open- and closed-slot rotors. (PA&S, June 1959, pp. 349-57.)

59-47. Development of a 230-Kv 20,000-Mva Oil Circuit Breaker. *F. L. Reese.* A new rating has been obtained with the dead-tank type of oil circuit breaker: 230 kv, 20,000 mva. This breaker, using previously proved principles, was subjected to an extensive test program. The description of the breaker and the results of the test program are presented in detail in the paper. The excellent results of the tests completely verified the rating assigned. (PA&S, Aug. 1959, pp. 449-55.)

59-50. New Current-Limiting Gap Extends Valve-Type Lighting-Arrester Performance. *J. W. Kalb, A. G. Yost.* A current-limiting gap has been incorporated in a newly developed valve-type lightning arrester. The result has been improved protective characteristics, durability, and reduced size. Some of the design and development test results are presented in this paper. (PA&S, Aug. 1959, pp. 462-57.)

59-51. Practical Computation of Single-Frequency Coupling Losses for Representative Field Conditions. *H. J. Fiedler, F. C. Krings, D. L. Weller.* Coupling losses represent an important part of the total losses in power-line carrier applications. Therefore, it is important to provide means for accurate computation of these losses. However, the loss in a coupling circuit is a complex function of several independent variables and because of this, coupling losses in the past have been empirically estimated. This paper presents nomograms and associated discussion which accurately determine the coupling losses with single frequency tuning when such factors as (1) frequency (both resonance and off resonance), (2) size of coupling capacitor, (3) load resistance (overhead lines and power cables), and (4) *Q* of the coupling circuit are considered.

Thus, the application engineer is pro-

vided with pertinent data which will permit him to apply power-line carrier coupling circuits properly utilizing single frequency tuning. (PA&S, Aug. 1959, pp. 455-61.)

59-53. Ferroresonance in Series Capacitor–Distribution Transformer Applications. *E. F. Kratz, L. W. Manning, Miles Maxwell.* A series of analog-computer and full-scale tests were made to determine the effects of various parameters on ferroresonance in series capacitor–distribution transformer applications. The parameters studied were capacitor compensation, source impedance, transformer magnetization characteristics, angle of energizing voltage, residual magnetization of transformer core, secondary load, and resistor shunting the capacitor.

From the tests it was concluded that for applications in the parameter range which might be reasonably expected, ferroresonance conditions which could damage the capacitor or the transformer may occur. If occasional damage is to be avoided, the equipment must be protected from ferroresonance. (PA&S, Aug. 1959, pp. 438-49.)

59-54. The Analysis of Sudden-Short-Circuit Oscillograms of Steam-Turbine Generators. *Dean Harrington, J. I. Wittlesey.* Oscillograms of armature current are obtained during sudden-short-circuit tests of synchronous machines. By assuming that the amplitude of the alternating component of the current is the sum of two exponentially decaying terms plus a nonvarying term, the oscillogram can be processed so as to obtain reactances and time constants of the machine. In the process of adapting hand methods of analyzing oscillograms, for the IBM *704* computer, it was found that in certain respects, the characteristics of steam turbine generators deviate from the ideal 2-exponential behavior. A process was developed which employs mechanized reading of oscillograms and analysis of the results by computer, and gives consistent and acceptable results. (PA&S, Aug. 1959, pp. 551-65.)

59-55. 240-Volts-to-Neutral Should Be Preferred for Utilization. *A. S. Anderson, Chase Hutchinson, S. J. Pearson.* The United States has lagged in its acceptance of higher utilization voltage for residential and commercial use. However, in the last 10 years it has gradually increased its application of 265/460 volts for 3-phase service to large commercial loads. The authors contend, based on the results of their study as summarized in this paper, that this level is wrong as it can never be applied economically to residential and small commercial loads. Hence it will be applied selectively, thus tending to perpetuate the present standard 120-volt-to-neutral level. If the 240-volt level is chosen, then some day in the future all residential and commercial usage can be at 240 volts to neutral. (PA&S, June 1959, pp. 252-65.)

59-57. Optimum Machine Design by Digital Computer. *G. L. Godwin.* Optimum design requires the solution of a set of nonlinear inequalities where many of the variables are not continuous functions. A technique has been developed for systematically surveying the design area and obtaining the optimum design as rapidly as possible. This program either produces complete designs or, when impossible requests are made, it prints the performance data for the nearest suitable designs.

Since uniformity of design has been obtained, it is possible to study the effects of changes to standard parts in order to improve formulas and design techniques. Production details have been assigned to a computer that is far more accurate and efficient than the engineer in executing routine work. (PA&S, Aug. 1959, pp. 478-88.)

59-97. Ferroresonance of Grounded Potential Transformers on Ungrounded Power Systems. *R. F. Karlicek, E. R. Taylor, Jr.* Potential transformers that have their primary windings connected in Y and grounded, on an otherwise ungrounded circuit, may oscillate following a voltage disturbance with the distributed capacitance to ground of the circuit. This oscillation, termed here as ferroresonance, may be of several frequencies and will persist if energy losses are not sufficiently high. This paper discusses this phenomenon and its adverse effects, and presents methods derived from analog computer and laboratory tests for determining the secondary resistive loading required to prevent the oscillation from being sustained. (PA&S, Aug. 1959, pp. 607-18.)

59-108. Progress in Extra-High-Voltage Power Transmission. *P. A. Abetti, S. B. Crary.* In Part I a review is presented of the present status of extra-high-voltage (EHV) power transmission (275 kv and higher) in this country and abroad. A forecast is made of the future requirements and developments of EHV transmission in the United States to 1977. It is concluded that (1) there will be continued and rapid expansion of EHV systems at the highest voltage presently used, 345 kv; (2) a higher voltage of the order of 460 kv will be introduced probably about 1962 in this country; and (3) a still higher voltage of the order of 650 kv may possibly be introduced about 1975. In Part II, the areas of technical work are identified and the problems of EHV technology are classified accordingly. The means which are available for the solution of these problems are then reviewed: analytical work, laboratory investigations, experimental lines, prototype EHV systems, and tests on the actual systems. It is concluded that all these means are necessary to obtain a proved solution. (PA&S, June 1959, pp. 357-71.)

59-140. A Hydrostatic Thrust-Type Shaft Seal for Hydrogen-Cooled Generators. *W. W. Gardner, A. Lehrkind, W. L. Ringland.* Hydrostatic lubrication of the thrust-type shaft seal for hydrogen-cooled turbine–generators provides much greater oil film thickness than earlier thrust-type seals. This reduces both power loss and oil requirements, and increases tolerance for dirt in the oil supply, as well as thermal distortion and manufacturing variations.

By suitable proportioning of the seal, inherent accommodation of a wide range of hydrogen pressure is obtained and centrifugal pressure developed in the rotating oil film is utilized to minimize oil flow to the hydrogen atmosphere. Extensive development and endurance tests preceded application of the seal to turbine–generators. (PA&S, Aug. 1959, pp. 653-59.)

59-155. Distribution Transformer Load Management. *P. G. Brittain.* The distribution transformer load management program of the Dallas Power & Light Company utilizes a demand kva calculated for each residential customer. These kva demands are computed from kwhr meter readings registered during the peak load season. A multiplying factor, to convert kwhr to kva, is obtained from a statistical study of metered data from sample transformers. An electronic billing computer and other accounting machines are then used in conjunction with the regular billing system card files to provide detailed load data for the entire residential distribution system. (PA&S, Aug. 1959, pp. 665-68.)

59-243. Automatic-Ratio-Control Transformer and Regulator. *J. S. Malsbary.* A stepless regulating system that has an error-correcting time measured in cycles for automatic-ratio-control transformers and regulators is described. Voltage control is effected by using a bridge composed of saturable reactors which are, in turn, controlled by magnetic amplifiers. The transformer described may be paralleled with another transformer (whether or not equipped with automatic voltage level control). The regulating system has no moving parts to require periodic maintenance. These transformers and regulators have been successfully applied on lines where closer and faster regulation than can be obtained with presently available equipment is required. (PA&S, June 1959, pp. 388-95.)

SCIENCE & ELECTRONICS DIVISION

59-118. Mathematics of Insulation-Aging Calculations. *L. C. Whitman, W. W. Whitman.* Equations are developed for the calculation of insulation aging in apparatus, recognizing that the temperature of the apparatus usually changes in accordance with an exponential relation. Insulation aging rate is based on the use of the Arrhenius chemical reaction rate theory, which relates insulation deterioration to the reciprocal of the absolute temperature. All aging values are in terms of relative aging, which assigns a value of unit aging to a specified temperature. The results using this method are compared with the usually made simplification of assuming rectangular temperature cycles and also with the assumption of a triangular temperature cycle. (C&E, Sept. 1959, pp. 308-18.)

INSTITUTE ACTIVITIES

Ground Is Broken in New York for New United Engineering Center

GROUND-BREAKING ceremonies for the United Engineering Center, a multimillion dollar, 18-story structure to be erected opposite the United Nations in New York City, were held Thursday, October 1, 1959, at 11:00 a.m. Former President Herbert Hoover, representing the older generation of engineers, shared earth-turning honors with a freshman engineering student from Hawaii, Jerry Fujimoto, who represented engineers of the future.

Planned to occupy the block between 47th and 48th Streets, on United Nations Plaza at First Avenue, the Center will house the headquarters of 18 major engineering societies whose combined membership is more than 300,000. Together, the societies are responsible for a major part of the nation's technical publications, industrial standards, and engineering conferences. Some of the groups are now housed at the Engineering Societies Building, 29 W. 39th St., New York, N.Y.

An Event of Great Importance

Mr. Hoover, who began his career as an engineer, said that engineers are "the foundation of security in our defense and in the increase of our standards of living and comfort." He spoke of the ground breaking as "an event of great national importance.

"Herein will be the constant exchange of discovery, improvements, and experience. It will play a great part in American life. It will serve all mankind."

He declared that the organizations constitute "a gigantic post-graduate course for engineers.

"I have attended this course for more than 60 years," he said, "with a certain amount of intellectual profit."

Mr. Fujimoto, an American citizen of Japanese extraction, enrolled this Fall at Rensselaer Polytechnic Institute (RPI), Troy, N. Y. He was described as a member of the newest engineering class, entering the oldest engineering college in the country from the newest state in the Union.

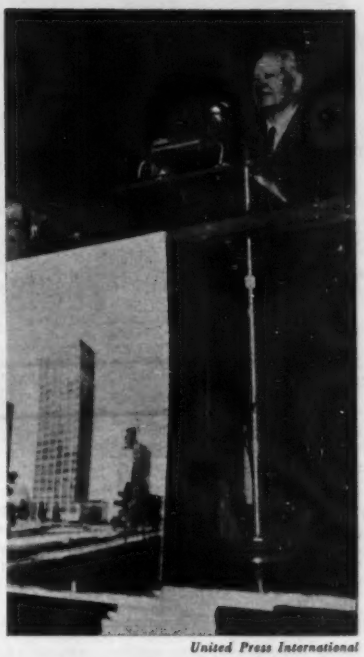
College officials revealed Mr. Fujimoto wrote, on applying for admission to RPI: "I have set my goal for the very top and I will seek it with all my might. There is the likelihood I will not reach it; but no matter what heights I may reach, I will be assured that it will be higher up the ladder than the height I might have reached if I were satisfied with mediocrity."

Mr. Fujimoto's father is a machinist with the Oahu Sugar Company of Hawaii. His home is in the town of Waipahu, on the island of Oahu, Hawaii.

The new structure, scheduled for completion in mid-1960, will be the largest undertaking ever attempted by the engineering profession.

Plans for the Center have been more than 8 years in the making. A fund-raising campaign has already achieved almost $5 million in contributions from industry and $3 million in contributions from individual engineers.

Andrew Fletcher, president of United Engineering Trustees, Inc. (UET), the organization that will own and operate the structure on behalf of the engineering societies, said: "The primary purpose of the new structure is to provide adequate working space for the headquarters staffs of the engineering groups, which carry on exten-



United Press International

►FORMER PRESIDENT Herbert Hoover was principal speaker at the ground-breaking ceremonies for the United Engineering Center. Attached to the speakers' platform is an architect's sketch of the structure to be erected on United Nations Plaza.

United Press International

EXPERIENCE AND YOUTH were combined as Herbert Hoover and Hawaii-born engineering student Jerry Fujimoto broke ground for the new United Engineering Center in New York. Performing the ceremony were: *(left to right, front row)* J. H. Foote, AIEE president; Mr. Fujimoto, Mr. Hoover, and Andrew Fletcher, president of United Engineering Trustees, Inc., who did not allow the rain to keep them from their assigned task of breaking ground for the multimillion dollar building. Standing behind the rope *(at left)* during the ceremony were: W. J. Barrett, AIEE past president, and C. H. Linder, AIEE treasurer.

United Press International

MORE THAN 1,000 persons witnessed the ground-breaking ceremonies for the United Engineering Center. Equipped to brave the inclement weather, the viewers assembled at the building site to listen to prominent persons from the engineering fraternity. Contributions from many of the 300,000 engineers represented by the participating groups and from industry will finance the $12 million structure.

sive publishing, research, and standardization programs." The second purpose is "to symbolize the growing strength and growing unity of the engineering profession." Mr. Fletcher presided at the ceremony.

Speakers were: W. F. Thompson, chairman of the Real Estate Committee of UET; R. E. Dougherty, chairman of the Member Gifts Campaign Committee; M. J. Kelly, chairman of the Industrial Building Fund Committee; and Mr. Hoover.

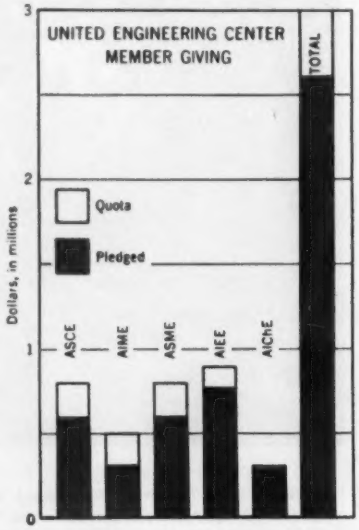
The Rev. J. J. O'Reilly, pastor of the Holy Family Church, E. 47th St., offered the benediction.

Ushers at the ceremony were student officers of the engineering societies at engineering schools in the Metropolitan New York area.

The Center will be the future home of the following engineering organizations: AIEE; American Society of Civil Engineers; American Institute of Mining, Metallurgical, and Petroleum Engineers; American Society of Mechanical Engineers; American Institute of Chemical Engineers; American Society of Heating, Refrigerating, and Air-Conditioning Engineers; Illuminating Engineering Society; American Institute of Consulting Engineers; American Welding Society; American Institute of Industrial Engineers; Society of Women Engineers; Municipal Engineers of the City of New York; UET; Engineering Societies Library; Engineering Foundation; Welding Research Council; Engineering Index; Engineers' Council for Professional Development; and Engineers Joint Council.

The building will have a gross area of 263,000 square feet and a net area of 180,000 square feet. Land for the structure was acquired in 1957. Since that time, major efforts of UET have been directed toward design of the building and fund-raising activities.

Jaros, Baum, and Bolles are the electrical and mechanical engineers for the new structure. Seelye, Stevenson, Value, and Knecht are the structural engineers. Shreve, Lamb, and Harmon Associates are the architects, and the general contractor is the Turner Construction Company.



THE BAR GRAPH shows the status of member giving as of October 2, 1959. All contributions to the United Engineering Center Building Fund are tax deductible.

Engineers Joint Council Reports on Consolidation Issue

Whether the two major federations in the engineering profession—Engineers' Council for Professional Development (ECPD) and Engineers Joint Council (EJC)—will be consolidated is an issue that will be determined by the close of this year.

The consolidation plan was the subject of an item that appeared in the September 9, 1959, issue of *Engineer*, a new publication compiled by EJC. Consolidation has been proposed by a joint committee of the two organizations.

EJC referred the proposal to its constituent societies, and received the following replies: Against consolidation—1; For consolidation—7; No action—2.

AIEE is opposed to consolidation of the two councils. In favor of the consolidation plan are: American Society of Civil Engineers (ASCE); American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME); American Water Works Association; American Society for Engineering Education (ASEE); American Institute of Chemical Engineers (AIChE); Society of American Military Engineers; and American Institute of Industrial Engineers. No action on this matter was reported by the American Society of Mechanical Engineers (ASME) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Common membership in the two councils are held by AIEE, ASCE, AIME, ASME, ASEE, and AIChE. Others, which are not EJC members, are: Engineering Institute of Canada, and the National Council of State Boards of Engineering Examiners.

Chairman Elected for New AIEE Division

Dr. R. C. Langford (M '55), chief engineer for research and development, Weston Instruments Division of Daystrom, Inc., has been elected chairman of the newly formed AIEE Instrumentation Division in New York.

With the upgrading of the former AIEE Instrument Committee to the status of a full division by AIEE directors, it will be Dr. Langford's responsibility to fully integrate the complete sphere of instrumentation within a definite group.

Dr. Langford received his Ph.D. degree from the University of London, and, after serving with the Admiralty during World War II, when he designed naval units with antiaircraft fire controls, he became project engineer at Sangamo Weston, England. He joined the former Weston Electrical Instrument Corporation, Newark, N. J., in 1952.

Author of several books on electronic instrumentation, Dr. Langford has held numerous committee posts with the major engineering societies. Currently, he is editor of the *Transactions* of the Institute of Radio Engineers (IRE) Professional Group on Engineering Management, chairman of the New York IRE Chapter on Engineering Management, and a member of the American Nuclear Society.

21 Session Themes Listed for Electrical Insulation Conference

THE 2ND National Conference on the Application of Electrical Insulation, sponsored by AIEE and the National Electrical Manufacturers Association, will be held December 8-10, 1959, in Washington, D. C.

The tentative technical program for the conference follows:

Tuesday, December 8

Morning Sessions

Distribution Equipment – Elevated-Temperature Materials

Session Chairman: L. W. Kirkwood

Assistant Chairman: K. G. Lageroff

Session Theme: Class H Dry-Type Transformers

Dry-Type Transformers. *W. W. Dornbush*, Pennsylvania Transformer Company.

A 220 C Insulation System for Dry-Type Transformers. *F. J. Brutt*, Westinghouse Electric Corporation.

The Evaluation of Impregnating Varnishes for 220 C Transformers. *D. H. Briggeman, G. I. Duncan*, General Electric Company.

New Class H Spacer Bars. *F. W. Bailey*, Union Carbide Corporation; *R. H. Kidney*, Polyglas Corporation.

Aluminum Wire. *R. R. Cope*, Aluminum Company of America.

Rotating Machinery—Testing and Evaluation

Session Chairman: P. Hernick, Electric Machinery Corporation

Assistant Chairman: Ernie Summers, Westinghouse Electric Corporation

Session Theme: A Key to Reliability—Thorough Evaluation

Development and Evaluation of Insulation Systems for D-C Machines. *W. B. Penn*, General Electric Company.

Compatibility of Magnet Wire Insulations and Epoxy Encapsulation Resins. *H. Lee*, The Epoxylite Corporation.

Testing and Evaluating Electrical Insulation for Use in Rotating Electric Machinery. *H. V. Howe*, Continental-Diamond Fibre Corporation.

Evaluation of Impregnating Varnishes. *J. F. Dexter*, Dow Corning Corporation.

Electronics—New Materials and Methods

Session Chairman: C. Harper

Session Theme: New Materials and Methods in Electronics

Dapon Resin—An Improved Diallyl Phthalate Material for Electrical and Dimensional Stability in Electronic Applications. *C. A. Heilberger, S. W. Jones, Jr., R. M. McFarland*, Food Machinery and Chemical Corporation.

Alumina Fluid Catalyst as a Potting Compound for Electronic Transformers. *R. S. Key*, Bell Telephone Laboratories.

Functional Temperature Limits of Electrical P.S.A. Tapes. *M. W. Hansen*, Minnesota Mining and Manufacturing Company.

Molding Compounds. *R. M. Soria*, Amphenol Research and Engineering Corporation.

Encapsulation with Alkyd Molding Compounds. *J. T. Long*, Allied Chemical Corporation.

Afternoon Sessions

Distribution Equipment – Elevated-Temperature Materials

Session Chairman: G. I. Duncan

Session Theme: Foreign Practices in Insulation Application

Rotating Machinery—Testing and Evaluation

Session Chairman: J. S. Askey

Session Theme: Evaluation of Insulating Materials

The Significance of Electric Strength of Rotating Machine Insulation. *C. L. Moses*, Westinghouse Electric Corporation.

Testing Methods for Flexible Insulations (Wrapped Bar Testing of Composite Insulation). *M. P. Koerner*, Owens-Corning Fiberglas Corporation.

Production Application of Epoxy Resins. *W. E. Harvey*, J. C. Dolph Company.

Innovation in Motorette and Fieldette Testing as Developed by the Elliott Company. *D. A. Addison, W. G. Stiffer*, The Elliot Company.

Electronics—New Materials and Methods

Session Chairman: R. Feuchtbaum

Session Theme: New Elevated-Temperature Wire Insulations

One-Component Epoxy Resins for Transformers. *L. A. Dixson*, Houghton Laboratories, Inc.

Flat High-Temperature Cable for Electronic Applications. *D. Preston*, Hughes Aircraft Company.

Flat High-Temperature Properties and Uses. *J. Case, R. Korb, V. Lazzaro*, Hughes Aircraft Company.

High-Temperature Performance of Wire and Cable Insulated with Teflon Fluorocarbon Resins. *J. P. Shoffner*, E. I. duPont de Nemours & Co. (Inc.); *J. Casey*, U. S. Navy Bureau of Ships.

How To Use High-Temperature Wire and Cable. *D. Tornello, F. Morocco*, Tensolite Company.

Wednesday, December 9

Morning Sessions

Distribution Equipment—New Materials and Methods

Session Chairman: W. J. Donaldson

Assistant Chairman: R. B. Knowles

Session Theme: New Insulating Materials for the Switchgear Industry

New Insulating Materials for Metal Clad Switchgear. *R. Frink*, Westinghouse Electric Corporation.

The New Look in Glass Polyester Premixes. *R. Jackson*, Glastic Corporation.

Switchgear Application for Glass Filament Wound Components. *R. E. Young*, Young Laboratories.

Moldings. *P. W. Jones*, Rostone Corporation

Heat and Flame Resistant Diallyl Phthalate Molding Materials. *F. C. Karas*, Mesa Plastics.

Rotating Machinery—Elevated-Temperature Materials

Session Chairman: A. J. Wiltjer

Session Theme: Elevated-Temperature Materials in Rotating Machinery

Electronics—Testing and Evaluation

Session Chairman: C. Kepple

Session Theme: Evaluation and Testing of Materials for Electronics

Afternoon Sessions

Distribution Equipment—New Materials and Methods

Session Chairman: L. C. Whitman

Assistant Chairman: W. H. Mutschler

Session Theme: Direction of Progress in Elevated-Temperature Distribution Apparatus

Direction of Progress in Elevated-Temperature Insulation for Distribution Apparatus. *G. A. Monito*, Westinghouse Electric Corporation.

Epoxy Enameled Magnet Wires. *H. L. Saums*, Anaconda Wire and Cable Company.

Progress in High-Temperature Applications of Epoxy Resin Insulation. *J. Delmonte*, Furane Plastics Company.

Progress in Silicone Insulations. *S. Hurley, Jr.*, General Electric Company.

Cyanoethylated Kraft—A Thermally Up-graded Cellulose for Transformer Applications. *J. C. Leslie*, General Electric Company; *N. L. Greenman*, Rogers Corporation; *H. W. Knudson*, Hollingsworth and Vose Paper Company.

Rotating Machinery—Elevated-Temperature Materials

Session Chairman: C. J. Herman

Assistant Chairman: J. A. Ruby

Session Theme: Elevated-Temperature Materials and Evaluation Methods

Improved Thermal Performance of Marine Generators Using New Insulating Materials. *C. R. Atkinson*, General Electric Company.

Thermal Life Studies of a New High-Temperature Coated Fabric. *T. A. Bombicino, R. S. Armstrong*, General Electric Company.

Insulation System for Low-Voltage Very-Low-Speed Rotating D-C Equipment. *J. S. David*, General Electric Company.

New Class B, Dacron Mat (Epoxy Treated) Mylar Insulation Composites. *J. A. Ruby*, Milam Electric Manufacturing Company.

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Electronics—Testing and Evaluation

Session Chairman: H. K. Graves

Session Theme: Dielectric Strength Testing

Dielectric Strength Test Equipment. *N. W. Edgerton*, Johns-Manville Corporation.

Conditioning for Dielectric Strength Tests. *K. Wechsler*, Westinghouse Electric Corporation.

Procedures for Measurement of Dielectric Strength. *H. S. Endicott*, General Electric Company.

Interpretation of Results of Dielectric Strength Measurements. *C. L. Craig*, Sperry Gyroscope Company.

Thursday, December 10

Morning Sessions

Distribution Equipment—Testing and Evaluation

Session Chairman: R. B. Goody

Session Theme: Testing Insulation in Switchgear

The Need for Improved Applied Insulation in Metal Clad Switchgear. *H. B. McClure*, Alabama Power Company.

Latest Development in Switchgear Insulation. *W. R. Axon*, Federal Pacific Electric Company.

Development of Tracking Resistant Glass Polyester Laminates and Molding Compounds. *G. R. Mitchell*, Glastic Corporation.

Selection and Testing of Thermal Setting Plastic for Cast Electrical Insulation. *R. R. Cook, R. Clark*. Reichhold Chemicals Company.

Rotating Machinery—New Materials and Methods

Session Chairman: J. L. Kuehlthau

Assistant Chairman: M. L. Lewis

Session Theme: Silicone Rubber for Motor Insulation

Consideration in the Production of Silicone Rubber Insulation for Form Wound Coils. *W. Lynch*, Moxness Products.

Bondable Silicone Rubber Tapes with Improved Electrical and Physical Properties. *R. A. Ward, J. W. Wetzel*, General Electric Company.

Properties of Silicone Rubber Dispersions and Self-adhering Tapes. *J. R. Rodgers*, Union Carbide Corporation.

Voltage Endurance of Silastic Insulation. *J. F. Dexter*, Dow Corning Corporation.

Application for Silicone Rubber in High-Voltage Electric Rotating Equipment. *G. Betzhold*, Allis-Chalmers Manufacturing Company.

Electronics—Elevated-Temperature Materials

Session Chairman: A. T. Hamill

Session Theme: Inorganic Insulation for 500 C

An Insulation System for 500 C Magnetic Amplifier. *C. F. Plasewicz*, Westinghouse Electric Company Military Electronics Division.

High-Temperature Inorganic Embedding Compound. *W. Cummings*, Emerson and Cuming Corporation.

CP 59-1295. High-Temperature Wire Insulation. *F. A. Satler, L. C. Scala*, Westinghouse Electric Corporation, research department.

High-Temperature Silica-Based Insulation. *J. D. Walton*, Engineering Experimental Station, Georgia Institute of Technology.

Afternoon Sessions

Distribution Equipment—Testing and Evaluation

Session Chairman: W. M. Terry

Assistant Chairman: N. W. Edgerton

Session Theme: Correlation of Functional Life Testing of Complete Apparatus and Testing and Evaluation of Material Components

59-1293. Functional Life Tests of Apparatus as Compared to Insulation Material Tests. *M. L. Manning*, South Dakota State College.

"C" Oil Resin Applications in Electrical Insulation. *R. G. Adams, H. Clark*, Esso Research and Engineering Company.

New Fast Curing Silicone Varnish. *R. E. Kincaid*, Dow Corning Corporation.

Application of Epoxy Insulation to the Electrical Power Field. *R. Smith*, Hysol Limited.

Rotating Machinery—New Materials and Methods

Session Chairman: D. E. Stafford

Session Theme: New Materials and Methods Dealing with Epoxy Resins

Thermal Endurance of Epoxy Encapsulated Magnet Wire. *E. W. Daszewski*, Essex Wire Corporation

Epoxy Applications in the Insulation of Field and Rotor Coils. *P. Lonseth*, General Electric Company, Ltd.

Strain Gage Evaluation of Flexible Epoxy Resins. *M. W. Hanson*, Minnesota Mining and Manufacturing Company.

Comparative Properties of Filled Epoxy Electrical Potting Compounds. *M. C. Reed*, Bakelite Company.

MK Coated Fabrics. *R. V. Einstman*, E. I. duPont de Nemours & Co. (Inc).

Electronics—Elevated-Temperature Materials

Session Chairman: C. L. Craige

Assistant Chairman: A. Blanck

Session Theme: Elevated-Temperature Printed Circuits

Heat Exposure and its Effect on Printed Circuit Materials. *L. A. Gunzaulhs*, Photo Circuits Corporation.

Glass Microfiber Reinforced Teflon Insulation Made by a Paper-Type Process. *N. L. Greenman, R. C. Berry*, Rogers Corporation.

Study of High-Temperature Resistance of Copper Clad Laminates. *J. F. Taylor, A. Haroldson*, Continental-Diamond Fibre Corporation.

Reliable Printed Circuitry Materials. *J. Monturo, L. Krause*, Arma Division, American Bosch Arma Corporation.

Printed Circuits on Ceramic Bases. *J. McManus, L. Ferreria*, Coors Porcelain Company.

Fortescue Fellowships Are Available for 1960-61

Funds have been made available for one or more Charles LeGeyt Fortescue Fellowships for 1960-61. The amount of the award has been fixed at $2,500. The awards are made to postgraduate students in the field of electrical engineering who have received their baccalaureate degree from a duly recognized technical school in the United States or Canada.

Candidates for the fellowships should file applications on the form provided by AIEE so that they reach the chairman of the Fellowship Committee by January 15, 1960. Awards will be made not later than March 1. Copies of the application forms are available at accredited colleges or by writing to the Secretary of the Professional Development and Recognition Department, AIEE, 33 W. 39th St., New York 18, N. Y.

The Charles LeGeyt Fortescue Fellowship, sponsored by AIEE, was established in 1939 as a memorial to Charles Fortescue in recognition of his valuable contribution to the electric power industry. To this end, the Westinghouse Electric Corporation, with which Dr. Fortescue was associated throughout his professional career, set up a trust fund of $25,000 to provide graduate fellowships in electrical engineering.

The successful candidates are selected by the AIEE committee which administers the fund.

It is intended that candidates shall pursue their studies at accredited engineering schools and engage in research problems meeting the approval of the Fellowship Committee. To be eligible, the student must have received a bachelor's degree from an accredited college by the time his work under the fellowship would begin, provided he does not hold or subsequently receive any other fellowship which carries a stipend greater than the tuition required by the institution at which the graduate work is to be undertaken.

EIA Reorganizes Its Engineering Department

F. R. Lack (M '37, F '48), former vice-president and director of Electronic Industries Association (EIA), Washington, D. C., and vice-president of Western Electric Company until his retirement in 1958, has been elected director of the EIA engineering department.

He will fill the position occupied for 25 years by Dr. W. R. G. Baker (AM '19, F '47, Member for Life), who will continue his advisory role to EIA as director emeritus of the department.

By virtue of his office, Mr. Lack has become an ex officio member of the Board of Directors.

Located in New York City, the EIA engineering department is administered by V. M. Graham (M '47), associate director.

Mr. Lack was awarded the 1959 EIA Medal of Honor for his many contributions to the advancement of the electronic industry.

AIEE Future Meetings

Mid-America Electronics Conference*
Hotel Muehlebach
Kansas City, Mo.
November 3-5, 1959

AIEE-IRE-ISA National Automatic Control Conference*
Sheraton Hotel
Dallas, Texas
November 4-6, 1959

Control Systems Components Conference*
Sheraton Hotel
Dallas, Texas
November 4-6, 1959

AIEE-IRE-ISA Electrical Techniques in Medicine and Biology Conference (Exhibits)*
Sheraton Hotel
Philadelphia, Pa
November 10-12, 1959

Appliance Technical Conference*
Biltmore Hotel
Los Angeles, Calif.
November 16, 1959

Magnetism and Magnetic Materials Conference*
Sheraton-Cadillac Hotel
Detroit, Mich.
November 16-19, 1959

AIEE-ASTM High-Voltage Cable Insulation Conference*
Governor Clinton Hotel
New York, N. Y.
November 18, 1959

AIEE-IRE-ACM Eastern Joint Computer Conference*
Statler Hilton Hotel
Boston, Mass.
November 30-December 3, 1959

AIEE-IRE Midwest Symposium on Circuit Theory*
Marquette University
Milwaukee, Wis.
December 1-2, 1959

AIEE-NEMA Second National Conference on Application of Electrical Insulation*
Shoreham Hotel
Washington, D. C.
December 8-10, 1959

AIEE-IRE-ASQC Symposium on Reliability and Quality Control*
Hotel Statler
Washington, D. C.
January 11-13, 1960

Winter General Meeting
Hotel Statler
New York, N. Y.
January 31-February 5, 1960
(Final date for †TP—Nov. 2, ‡CP Syn.—Nov. 17, CPMs—Nov. 27)

AIEE-IRE-U of P Solid State Circuits Conference*
University of Pennsylvania
Philadelphia, Pa.
February 10-12, 1960.

Engineering Aspects of Magnetohydrodynamics Conference
University of Pennsylvania
Philadelphia, Pa.
February 18-19, 1960
(Final date for †TP—Nov. 20, ‡CP Syn.—Dec. 4, CPMs—Dec. 15)

AIEE-IRE-AEC-NBS Scintillation Counter Conference
Shoreham Hotel
Washington, D. C.
February 25-26, 1960
(Final date for †TP—Nov. 27, ‡CP Syn.—Dec. 11, CPMs—Dec. 22)

EJC Nuclear Congress
New York, N. Y
April 3-8, 1960

Southwest District Meeting
Shamrock-Hilton Hotel
Houston, Texas
April 4-6, 1960
(Final date for †TP—Jan. 4, DPMs—Jan 29)

Rockets and Missiles Conference
Hotel Baker
Dallas, Texas
April 11-13, 1960
(Final date for †TP—Jan. 12, ‡CP Syn.—Jan. 26, CPMs—Feb. 5)

East Central District Meeting
Daniel Boone Hotel
Charleston, W. Va
April 12-14, 1960
(Final date for †TP—Jan. 4, DPMs—Feb 5,

AIEE-ASME-IRE Automatic Techniques Conference
Sheraton-Cleveland Hotel
Cleveland, Ohio
April 18-20, 1960
(Final date for †TP—Jan. 19, ‡CP Syn.—Feb 2, CPMs—Feb. 12)

Great Lakes District Meeting
Pfister Hotel
Milwaukee, Wis.
April 27-29, 1960
(Final date for †TP—Jan. 28, DPMs—Feb. 22)

North Eastern District Meeting
Sheraton Biltmore Hotel
Providence, R. I
May 2-4, 1960
(Final date for †TP—Feb. 2, DPMs) —Feb 26)

AIEE-IRE-ACM Western Joint Computer Conference
Jack Tar Hotel
San Francisco, Calif.
May 3-5, 1960
(Final date for †TP—Feb. 3, ‡CP Syn.—Feb. 19, CPMs—Feb. 29)

AIEE-IRE-EIA-WCEMA Electronic Components Conference
Washington, D. C.
May 10-12, 1960
(Final date for †TP—Feb. 10, ‡CP Syn.—Feb. 26, CPMs—March 7)

Farm Electrification Conference
Sheraton-Fontenell Hotel
Omaha, Nebr.
May 10-12, 1960
(Final date for †TP—Feb. 10, ‡CP Syn.—Feb. 26, CPMs—March 7)

Electrical Problems in the Cement Industry Conference
Pfister Hotel
Milwaukee, Wis
May 17-19, 1960
(Final date for †TP—Feb. 17, ‡CP Syn.—March 4, CPMs—March 14)

Summer General Meeting
Chalfont-Haddon Hall
Atlantic City, N. J.
June 19-24, 1960
(Final date for †TP—March 21, ‡CP Syn.—March 31, CPMs—April 15)

Pacific General Meeting
El Cortez Hotel
San Diego, Calif.
August 8-12, 1960
(Final date for †TP—May 10, ‡CP Syn.—May 20, CPMs—June 3)

Fall General Meeting
Morrison Hotel
Chicago, Ill.
October 9-14, 1960
(Final date for †TP—June 10, ‡CP Syn.—July 21, CPMs—Aug. 5)

*Final date for submitting papers—closed

†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

**Transactions and conference papers must conform to the requirements in *Author's Guide*.
For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York 18, N. Y.**

Program Plans Formulated

John Tyner

CHICAGO SECTION, AIEE, helmsmen for 1959-60 mapped out program plans at the kickoff dinner meeting which was attended by more than 75 committee members and chairmen. Shown are *(left to right)*: 1959 Fall General Meeting officers—E. H. Finch, Sargent & Lundy, chairman; D. E. Skyllingstad, Kerite Company, treasurer; and L. E. Randall, General Electric Company, secretary; also, E. R. Whitehead, Illinois Institute of Technology, member, Advisory and Nominating Committees; R. B. Gear, Commonwealth Edison Company, chairman, Advisory Committee, and District No. 5 vice-president; F. A. Cox, Commonwealth Edison, Section chairman; W. T. Larner, Illinois Bell Telephone Company, Section secretary; E. Rodgers, Commonwealth Edison, Power Committee member and chairman of the Advisory Committee for Engineering Societies Personnel Service, Inc. (ESPS), representing the Chicago Section; F. G. Varenhorst, Illinois Bell Telephone, ESPS representative; and J. H. Enenbach, Illinois Bell Telephone, Section program chairman and vice-chairman of the National Electronics Committee.

Midwest Symposium on Circuit Theory

Scheduled December 1-2, Marquette University

THE 4TH MIDWEST Symposium on Circuit Theory, sponsored by AIEE and the Institute of Radio Engineers, will be held December 1-2, 1959, at Marquette University, Milwaukee, Wis.

The tentative program for the symposium follows:

Tuesday, December 1

8:00 a.m. Registration

Brooks Memorial Union, 620 N. 14 St.

8:30 a.m. Opening Address

Introduction by Dr. J. D. Horgan, director, department of electrical engineering, Marquette University.

A. B. Drought, dean, College of Engineering, Marquette University

9:00 a.m. Session I—On Analysis of Networks

Chairman: Ray Wainwright, Goodall Electric Corporation

A Primary and Secondary Aspect of the Equations of Electric Networks. *M. B. Reed, M. L. Wolla,* department of electrical engineering, Michigan State University.

Determination of Transient Response in Electric Circuit Analysis by Use of Mikusinski's Operational Analysis. *K. D. Struthers, T. J. Higgins,* department of electrical engineering, University of Wisconsin.

Axiomatic Formulation of Circuit Analysis. *W. M. Brown,* department of electrical engineering, University of Michigan.

11:45 a.m. Lunch

Brooks Memorial Union, Rooms 101-102

1:30 p.m. Session II—On Realizability and Synthesis

Chairman: Prof. A. B. Macnee, department of electrical engineering, University of Michigan.

Simplified Formulation of the Properties (Foster and other) of the Driving Point Impedance of LC Networks. *L. C. Wilcox, M. B. Reed,* department of electrical engineering, Michigan State University

Low Q Filters. *Prof. R. O. Rowlands,* Ordnance Research Laboratory, Pennsylvania State University.

Synthesis of Grounded Two-Terminal-Pair RLC Networks. *S. L. Hakimi,* department of electrical engineering, University of Illinois.

Passive Network Synthesis by a Matrix Transformation. *R. P. Schuh,* Engineering Experiment Station, Oregon State University.

An Extension of Prony's Method to Frequency Domain Approximation. *J. B. Cruz,* department of electrical engineering, University of Illinois.

6:30 p.m. Banquet

Brooks Memorial Union

Guest Speaker: (To be arranged)

Wednesday, December 2

8:30 a.m. Session III—From Analysis to Design

Chairman: E. W. Hobbs, McDonnell Aircraft Corporation

A Useful Extension of the Nyquist Criterion to Stability Analysis of Multiloop Feedback Amplifiers. *B. R. Meyers,* department of electrical engineering, University of Waterloo, Canada.

Topological Consideration of the Realizability of a Communication Network. *Omar Wing,* department of electrical engineering, Columbia University.

Approximations to Wiener Optimum Filters and Predictors. *F. J. Beutler,* aeronautical engineering department, University of Michigan.

Design of Combinational Switching Circuits Using an Iterative Configuration. *D. L. Epley,* department of electrical engineering, University of Illinois.

11:30 a.m. Lunch

Brooks Memorial Union

1:30 pm. Session IV—Of Active Networks

Chairman: Prof. M. B. Reed, department of electrical engineering, Michigan State University.

Recent Advances in Active Network Synthesis. *M. E. Van Valkenburg,* department of electrical engineering, University of Illinois.

Multiterminal Representations in the Analysis of Control Systems. *R. C. Dubes,* department of electrical engineering, Michigan State University.

Multiterminal Representations in the Analysis of Electronic Circuits. *D. P. Brown, J. J. Lang,* department of electrical engineering, Michigan State University.

The Analysis of Large Systems Using Subsystems as Components. *W. A. Blackwell, H. K. Kesavan,* department of electrical engineering, Michigan State University.

For further information contact: Stanley Krupnik, Jr., assistant director—department of electrical engineering, Marquette University, Milwaukee 3, Wis.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grade, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

E. B. Robertson Honored at Luncheon in Dallas, Texas

Forty-sixth recipient of honorary membership in AIEE, Elgin Barnett Robertson (M '24, F '45) was feted August 11, 1959, at a luncheon given for him at the Engineers Club in Dallas, Texas, by the North Texas Section.

Mr. Robertson, who is president of Elgin B. Robertson, Inc., of Dallas, was presented with a copy of the original resolution which was passed in June 1959 by the Institute's board of directors, which elected him an honorary member. Other notables who have been awarded this recognition include such great engineers and scientists as Sebastian Z. de Ferranti, Guglielmo Marconi, Thomas A. Edison, Herbert Hoover, Marshal Ferdinand Foch, Vannevar Bush, Edwin H. Armstrong, Royal W. Sorensen, the late Deputy Secretary of Defense Donald A. Quarles, and Luigi Emanueli.

Mr. Robertson was born June 4, 1893, in Meridian, Texas, and received a B.S. degree in electrical engineering from the University of Texas in 1915.

Immediately after graduation, he was employed by Westinghouse Electric and Manufacturing Company, now Westinghouse Electric Corporation, as a design engineer in the Power Transformer Division. In 1920, he was employed by the Railway and Industrial Engineering Company as chief electrical engineer to design and develop high-voltage switchgear. In 1924, he was elevated to the position of division manager.

He established the Elgin B. Robertson Company in 1928 to provide engineering and sales service to the electrical industry in the Southwest. In 1939, he organized the Plastics Manufacturing Company, and, under his guidance, this company developed optically clear plastic materials during World War II for use in aircraft. The company received many military citations for this service.

During World War II, Mr. Robertson was selected as Southwest regional manager of the War Production Board, Utilities Division.

He was selected as "Engineer of the Year" in 1954 at Dallas for his contributions to the engineering profession. Southern Methodist University honored him in 1954 with the degree of Doctor of Electrical Engineering. He is a member of Eta Kappa Nu. He has served as president and director of the Texas Society of Professional Engineers, and on its Inter-Society Relations, Inter-Professional Relations, and Objectives Committees.

He is a member of the AIEE Professional Conduct Committee (1957-60) and Recognition Awards Committee (1958-61).

Mr. Robertson has been an AIEE president (1953-54) and director (1947-56). He served on the following AIEE committees: Membership (1944-46); General Applications Division (1947-51); Registration of Engineers (1946-52, chairman 1949-51); Planning and Co-ordination (1946-53, chairman 1952-53); National Bureau of Engineering Registration Advisory Board (1949-51); Professional Division Advisory (1949-51); Lamme Medal (1951-54); Edison Medal (1952-59, chairman 1957-59); Executive (1952-56, chairman 1953-54); John Fritz Medal (1956-58); Administration Department (1956-58); and Professional Development and Recognition (1957-59).

Carl Poynter, Photography

PRESENTATION of the original resolution electing E. B. Robertson an honorary member of AIEE was made at a luncheon this Summer in Dallas, Texas. Members who attended were: (*seated, left to right*) J. B. Robuck, R. T. Martin, G. N. Pingree, J. L. Sandlin, P. G. Wallace, Mr. Robertson, Lee Cook, (*standing, left to right*) Joe Mann, Clarence Maas, Paul Neblett, George Smith, Jr., L. J. Blaize, J. L. Pratt, T. D. Thomas, and H. L. Reynolds.

HONORARY membership in the AIEE was bestowed upon E. B. Robertson (*left*) in a resolution presented to him by P. G. Wallace (*center*), immediate past director of AIEE, and J. L. Sandlin (*right*), chairman of the North Texas Section, who arranged the luncheon meeting.

Carl Poynter, Photography

Technical Papers Invited for 1960 ECC

A call has been made for technical papers for the annual Electronic Components Conference (ECC), scheduled for May 10-12, 1960, in Washington, D. C., under the sponsorship of AIEE, the Institute of Radio Engineers, the Electronic Industries Association, and the West Coast Electronic Manufacturers Association.

The 1960 meeting places principal emphasis on development, theory, production, and reliability of new electronic components of all kinds. The theme of the conference—Electronic Components: Art and Science—will be developed in the program to show how the past art of component making is being augmented by the highest technical skills and scientific disciplines.

Abstracts of papers dealing with the following fields are invited: semiconductors (rectifier diodes, tunnel diodes, compound formation, etc.); composite component circuits (molecular electronics, microminiaturization); thin film components (magnetic, conductive, dielectric, semiconductor); components-systems integration; magneto-optics; cryotrons and cryogenics; ferroelectric-ferromagnetic devices; tubes (klystrons, traveling wave, linear magnetron, and nuvistor); thermoplasticity; electroluminescence; square hysteresis loop materials; and thermoelectric power and devices.

Abstracts of 150-200 words should be submitted by December 15, 1959. Manuscripts of selected papers are due by February 1, 1960. These should be sent in triplicate to: G. B. Devey, technical program chairman, Sprague Electric Company, North Adams, Mass.

Philadelphia Lauds AIEE on Its 75th Year

A tribute was paid AIEE by the City of Philadelphia on September 30, 1959, at noon, in the reception room of Mayor Richardson Dilworth, Philadelphia, Pa.

The occasion was the commemoration of AIEE's 75th Anniversary Meeting which was to be held October 7, 1959, at the Franklin Institute.

About 100 members of AIEE were present to witness the ceremony during which J. E. Francis, deputy commissioner of the department of public property, Philadelphia, made the formal presentation of the tribute, on the mayor's behalf, to R. S. Hewett, chairman of the Philadelphia Section, AIEE.

The tribute reads as follows:

City of Philadelphia

Tribute

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Electricity is an immeasurably powerful giant whose energies illuminate our cities, hurl voices and pictures across a continent, do a thousand tasks a day in our homes, spark our huge engines of transportation on land, sea, and in the air, and carry us to new frontiers of knowledge.

This giant was once mysterious, forbidding, and unharnessed. One group of brilliant, dedicated, and visionary men—the electrical engineers of our nation—shares the fullest credit for our mastery of electricity. In an incredibly short span of years, these masters of science and technology have developed the electric light, the telephone and the electric motor from novelties to commonplace essentials of modern life.

Philadelphia is particularly proud that on October 7, 1884—75 years ago to the day—the American Institute of Electrical Engineers held its first technical meeting in our city. This distinguished organization, which numbered Thomas Edison, Charles Steinmetz, Alexander Graham Bell, and George Westinghouse among its early members, now counts on an international membership of more 60,000.

The American Institute of Electrical Engineers is meeting in Philadelphia today to mark its 75th Anniversary. It is fitting that the City of Philadelphia pay tribute to these eminent engineers who have contributed so heavily to the American standard of living.

RICHARDSON DILWORTH
Mayor

FREDERIC R. MANN
City Representative

October 7, 1959

THE TRIBUTE to AIEE from the City of Philadelphia was presented to R. S. Hewett (*center*), chairman of the Philadelphia Section, AIEE, by J. E. Francis (*left*), deputy commissioner of the department of public property, Philadelphia, on behalf of the mayor. R. L. Halberstadt (*right*), vice-chairman of the Philadelphia Section, is chairman of the 75th Anniversary Committee, AIEE.

Index Provides Summaries of Engineering Publications

The indexing of papers in the Engineering Societies Library is handled by the Engineering Index, which is a nonprofit organization to whose support AIEE contributes. Since 1885, the Engineering Index has provided the most comprehensive indexing and abstracting service available to engineers and other specialists who must keep informed of technological developments all over the world.

The Engineering Index employs a staff of qualified editors who review more than 1,500 periodicals and society transactions, as well as a large number of bulletins and reports of Government bureaus, schools, institutes, and research organizations. Publications in all branches of engineering and in all languages are reviewed. Articles which concern the application of engineering methods and concepts to any phase of the economy—and which are authoritative, informative, and useful—are abstracted.

The Abstracts are easy to use. For each article reviewed, the following information is printed on a 3 by 5 library card:

(a) Subject heading classification
(b) Title of article and name of author
(c) Name and date of publication
(d) Brief summary of the article

Subscribers to individual divisions receive all pertinent abstracts once a week. Subscribers to the complete service receive their abstracts daily—about 30,000 a year.

All publications reviewed are permanently filed in the Engineering Societies Library. The Library—which is open to the public—supplies, at minimum cost, photoprints, microfilm, and translations of the complete text of any article abstracted by the Engineering Index.

Since the Engineering Index covers all of engineering, its service is divided into 249 "Field of Interest" Divisions. The subscriber who wants information in certain areas only, may take only the divisions he needs. The "Field of Interest" classification is for the convenience of subscribers in ordering particular divisions. For filing purposes, however, the literature is classified according to a standard list of subject headings. This makes it relatively simple to incorporate the abstracts into most reference files. The complete list of subject headings is supplied free to "Complete Service" subscribers and may be purchased by others—both subscribers and nonsubscribers.

Subscribers use Engineering Index in the following way:

Libraries. Engineering Index offers libraries, both public and private, a ready-made index to much of the world's technological literature. In libraries with extensive collections of technical journals, the Index is a valuable key. Where there is no technical collection, or only a small

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one, the Index enables the library to serve many more users than it could otherwise. By generating requests for publications, it may indicate to the librarian where to begin acquisitions.

Industrial Firms. The major use of the Index is in industry where the pace of technological development demands a rapid means of keeping informed. In addition to its use in company libraries, some of the functions Engineering Index performs for industrial subscribers are:

General employee education. One large firm, for instance, subscribes to the complete service, and, according to job interest, reprints and distributes the cards to technical personnel. Other companies reprint the abstract information in their own abstract bulletins.

Research and Development. Here, where knowledge of technical developments can be critical, Engineering Index enables engineers to keep current without reading hundreds of publications.

Public Relations. Service organizations frequently subscribe to the Index to keep informed and to be able to answer consumer inquiries relating to their field.

Trade Associations. A subscription to one or several Engineering Index Divisions is an inexpensive way for a trade or industry organization to keep alert to developments which it can pass on to member companies. Some subscribers in this category also use the Index to keep a check on publicity received by members.

Government Bureaus. Many federal, state, and local government agencies are among Engineering Index subscribers. Included are military departments, experimental stations, departments of sanitation, highways, air pollution control, and water resources.

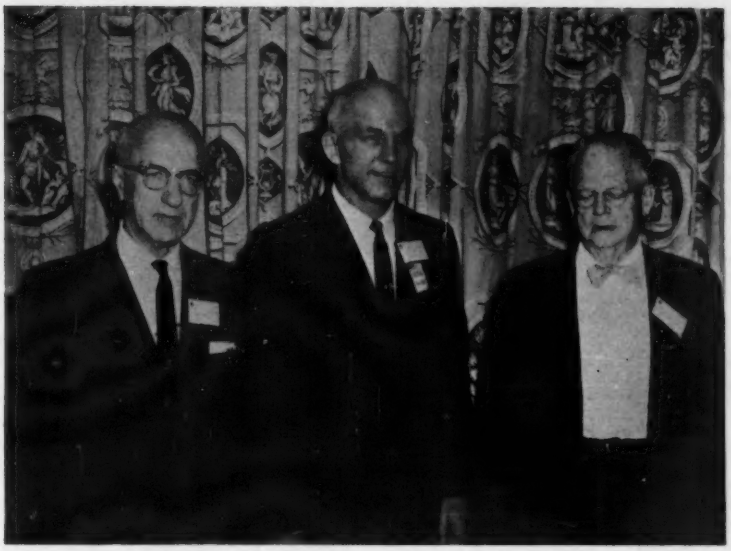
Schools and Universities. Not only school libraries but also individual departments and faculty members subscribe to the Index for their own purposes.

Individuals. Many engineers and technological specialists subscribe to the Index personally simply to keep informed, or for reference and bibliographical help on specific projects.

The cost of the Engineering Index is economical and varies according to the volume of abstracts prepared from the special field in which the subscriber is interested. The literature abstracted originates in 44 countries and is published in 22 languages other than English. The space of time elapsing from the receipt of the publication until the abstract is distributed is reasonably brief and compares favorably with other services.

The Engineering Index Catalog which can be obtained free by writing to The Engineering Index, 29 W. 39 St., New York 18, N.Y., will explain how simple it is to obtain what is needed from the mass of engineering information published in current technical engineering literature, no matter where it is printed. It is furnished in such brief and concise form that it will conserve time, energy, and expense, and keep one fully informed of what is worth while and pertinent to a particular interest.

The Engineering Index Service cards subsequently appear as a bound volume cumulating all of the references of the year. This volume, now in its 75th year, is an internationally accepted digest of technological literature prepared for engineers, research workers, and students. The Engineering Index has always been industry's authentic guide to the periodical technical literature. Today, it still stands unrivaled. Engineers consider it a vital part of their reference equipment.



"ELECTROMATION" was the theme for the 1959 AIEE 6th Electrical Conference of the Petroleum Industry. Among those attending the conference were: (left to right) J. H. Foote, AIEE national president; L. W. Swanson, chairman of the Long Beach Conference Executive Committee and director of administration of the Los Angeles Section, AIEE; and Dr. Royal W. Sorenson, AIEE past national president and honorary president of the Royal W. Sorenson Fellows of the Los Angeles Section. Headquarters for the 4-day conference was the Wilton Hotel in Long Beach, Calif.

6th Electrical Conference of Petroleum Industry Held

Do electrons control our destiny?

Can they guide the production, processing, and movements of petroleum? How?

These questions were answered for conferees attending the 1959 AIEE 6th Electrical Conference of the Petroleum Industry. Jointly sponsored by the Petroleum Industry Committee of AIEE and the Los Angeles Section, AIEE, the conference was held at the Wilton Hotel, Long Beach, Calif., August 23-26, 1959.

J. H. Foote, AIEE national president, made the opening address at the first general session.

Keynote speakers, A. F. Vinson and J. F. Davenport, talked of the manufacturer's and the electric utility's roles in petroleum industry "electromation." Mr. Vinson is vice-president and group executive, General Electric Company; Mr. Davenport is executive vice-president, Southern California Edison Company.

K. E. Kingman, director and senior vice-president, Union Oil Company, spoke of the present and future of electromation in the petroleum industry.

L. W. Swanson was conference Executive Committee chairman.

The Annual Electrical Conference of the Petroleum Industry provides electrical engineers with invaluable training on recent developments and progress in the industry. This training is not available through any other source.

Subcommittee Formed on Electric Power Sources

The organizational meeting of the newly formed Electric Power Sources Subcommittee of the AIEE Aero–Space Transportation Committee (ASTC) was held September 24-25, 1959, at the Naval Research Laboratory, Washington, D. C.

The scope of this subcommittee is twofold:

1. The treatment of matters relating to the electric power sources for aero–space applications.
2. The preparation of design guides, standards, and test codes.

D. H. Scott of Baltimore, Md., chairman of ASTC, was present at the meeting. Officers of the new subcommittee are: A. J. Wesolowski of Phoenix, Ariz., chairman, and R. R. Miille of Lima, Ohio, secretary.

At the September meeting, areas of endeavor were formulated and specific tasks were assigned to the membership. The next gathering was scheduled for February

in New York at the AIEE Winter General Meeting.

Members of the subcommittee were chosen from industry and universities for their proficiency in this field.

AIEE members and groups have been invited to send questions and problems dealing with electric power sources for air and space vehicles to the subcommittee chairman. His address is: A. J. Wesolowski, AiResearch Manufacturing Company of Arizona, Sky Harbor Airport, Phoenix, Ariz.

Moderator: E. G. Pereboom, engineering department, Missouri Valley District, Westinghouse Electric Corporation, Kansas City, Mo.

Transmission Considerations in Connection with Furnishing Network Television. *E. E. Snyder*, American Telephone and Telegraph Company.

The Convair *CV-880* Electrical System. *Wilbur East*, General Electric specialty control department, Waynesboro, Va.

Static Switching in Industrial Control. *W. M. Brittain*, co-ordinated digital development control engineering department, Westinghouse Electric Corporation, Buffalo, N. Y.

AIEE Kansas City Section To Participate in MAECON

The Kansas City Section of AIEE has arranged a session on "Transmission and Control Systems" as one of the features of the Mid-America Electronics Conference (MAECON) to be held November 3-5, 1959, in the Municipal Auditorium, Kansas City, Mo.

The AIEE session is the 9th on the program, which consists of 16 sessions and is being given under the sponsorship of the Kansas City Section of the Institute of Radio Engineers. Session No. 9 will be held Wednesday, November 4, at 1:30 p.m. in the West Room of the Municipal Auditorium.

The tentative program of the AIEE session follows:

Committee to Nominate Officers for 1960 Election

For the nomination of officers to be voted upon in the Spring of 1960, the AIEE Nominating Committee will meet in New York, N. Y., February 1, 1960. The officers to be elected are: a President, a Treasurer, three Directors, and seven Vice-Presidents, one from each of the odd-numbered geographical Districts. Fellows only are eligible for the office of President; Members and Fellows for the offices of Vice-Presidents, Directors, and Treasurer.

To guide this committee in performing its constituted task, suggestions from the membership are, of course, highly desirable. To be available for consideration of the committee, all suggestions must be received by the Secretary of the committee at Institute headquarters, not later than December 15, 1959.

In accordance with the provisions in the Constitution (C) and Bylaws (B), quoted in the following paragraphs, actions relating to the organization of the Nominating Committee are now under way:

C60.010. Nominating Committee. The Nominating Committee is composed of voting members, as defined in C20.110, selected by and representing parts of the Institute as follows:

C60.011. Districts have one representative each.

C60.012. Technical Divisions have one representative each.

C60.013. Board of Directors has representatives not exceeding the number of the Technical Divisions.

C60.014. Secretary. The Executive Secretary of the Institute acts as Secretary of the Nominating Committee, without vote.

C60.020. Nominations. The Nominating Committee meets and nominates candidates for Institute offices according to instructions contained in the Bylaws. The committee names one candidate for each vacancy in the office of President, Treasurer and Directors. It includes in its slate such candidates for Vice-Presidents as have been nominated by the Executive Committees of the Districts concerned. If a District fails to nominate a candidate for Vice-President, the Nominating Committee nominates a candidate from the District concerned. Additional nominations for any office may be made by a written petition of 25 or more voting members, in accordance with rules set forth in the Bylaws. For the office of Vice-President, the petitioners must be from the District concerned.

B27. During September of each year, the secretary of the Nominating Committee shall notify the chairman and secretary of the executive committee of each geographical District, and the chairman and secretary of each technical division committee that, by December 15th of that year, each District and each technical division should select a representative to serve as a member of the AIEE Nominating Committee and an alternate to serve if the representative is unable to attend the meeting of the Nominating Committee. The names of representatives and alternates, so selected, should be transmitted by the above designated officers to the secretary of the Nominating Committee by December 15th.

During September of each year, the secretary of the Nominating Committee shall notify the chairman and secretary of the executive committee of each geographical District in which there is, or will be during the year, a vacancy in the office of Vice-President that, by December 15th of that year, a nomination for a Vice-President in that District made by the District executive committee should be in the hands of the secretary of the Nominating Committee.

Between October 1st and December 15th of each year, the Board of Directors shall choose a number of its members, not exceeding the number of technical divisions, to serve on the Nominating Committee, and notify the secretary of the Nominating Committee of the names of the members so chosen.

The secretary of the Nominating Committee shall give the members so selected not less than 10 days' notice of the first meeting of the committee, which shall be held not later than February 15th. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. To insure that full consideration be given to all suggestions from the general membership, they must be in the hands of the secretary of the committee by December 15th. The nominations as made by the Nominating Committee shall be published in the April issue of *Electrical Engineering*, or otherwise mailed to the Institute membership not later than the last week in March.

C60.021. Candidates for any office must hold a grade of membership which entitles them to serve if elected.

B28. Petitions proposing the names of candidates as independent nominations for the

Fellow Diplomas Awarded

AIEE FELLOW diplomas were presented to K. L. Wheeler (*left*) and C. A. Martin (*right*) at a meeting of the Cleveland Section. The presentation was made by W. L. Chase (*center*), vice-president of District 14. Both transfers to the grade of Fellow were approved June 26, 1959, at the Board of Directors meeting. Mr. Wheeler is manager of the plant and substation engineering department of the Cleveland Electric Company. Mr. Martin is vice-president of the W. W. Clark Corporation.

various offices to be filled at the ensuing election, in accordance with C60.020, must be received by the secretary of the Nominating Committee not later than March 15th of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

B28.1. On or before April 15th of each year, the Executive Secretary shall mail to all qualified voters an official ballot on which are to be listed all eligible candidates, nominated as provided in C60.020. The candidates of the Nominating Committee shall be appropriately designated as such. Any nominee may, prior to the printing of the ballots, withdraw his name by written request to the Executive Secretary, whereupon that fact shall be suitably indicated upon the ballot.

The voting for each office shall be restricted to the nominees for the office as printed on the ballot. When there is a contest for any office, the ballot shall be accompanied by an envelope on which shall be printed the title of the Institute, the name and address of the Executive Secretary, and the words, "Official Voting Envelope—Enclosing a Ballot Only." All names voted for shall be written, printed, or otherwise marked on a single ticket or ballot, which shall be enclosed in a sealed, unmarked, and unidentified inner envelope of any suitable character, which shall in turn be enclosed either in the "Official Voting Envelope" (received from the Executive Secretary), or any other envelope, marked on its face, "Non-Official Voting Envelope—Enclosing a Ballot Only." The outer envelope of either class shall be identified by the name of the sender, shall be sealed, and in order to be counted, shall reach the Executive Secretary not later than the first day of June.

In the even. of no contest for any office, the slate of the Nominating Committee, in the form of a ballot, and having a reference to the biographies of the candidates in *Electrical Engineering*, shall be mailed to the voting members with the dues bill.

B28.2. The ballot shall provide a place where the entire slate of nominees can be voted with a single mark if there is no choice to be made between any of the candidates. The balloting should be secret in the case of a contest. The ballots shall be checked for ineligible voters only in the case of contest.

B28.3. The President, during the month of May, shall appoint, subject to the approval of the Board of Directors, a Tellers Committee. This committee shall be selected from voting members. Members of the Board of Directors, members of the Nominating Committee or their alternates or any nominee appearing on the ballot, or petitioners of a nominee, are ineligible to act as tellers. Other appointees as tellers are authorized by written petition delivered to the Executive Secretary on or before the first day of May. A minimum of 20 signatures of voting members is required. A petitioner is eligible to sign only one such petition. Each signer shall have the qualifications of a teller.

The Committee of Tellers shall meet at the office of the Institute as soon after the first day of June as possible and prepare an Election Report made out in duplicate, one copy filed with the Executive Secretary and the other copy with the Chairman of the Tellers Committee and kept sealed until presented to the presiding officer of the ensuing Annual Meeting. In the absence of the Chairman of the Committee, the Executive Secretary will present the duplicate copy of the Election Report. The Tellers' Election Report shall give the sum total of the ballots received and shall designate this total as a vote for the entire slate of officers where there are no alternative candidates. Only in the case of a contest shall an individual count be made. The presiding officer at the Annual Meeting shall cause the report to be read, and shall declare those duly elected in accordance with the results of the vote as presented in the report.

B28.4. The President shall decide the number of Tellers for each election. The Executive Secretary is authorized to prepare the ballots for counting on a business machine where feasible.

(Signed) N. S. Hibshman
Executive Secretary

AIEE FELLOWS ELECTED

Charles Kingsley, Jr.* (AM '30, M '36), associate professor of electrical engineering, Massachusetts Institute of Technology (MIT), Cambridge, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the teaching of electrical engineering and to the theory of electrical machinery." Following graduation from MIT in 1927 with the degree of S.B. in electrical engineering, he entered the student engineering training course of General Electric Company. In September 1928, he returned to MIT as a research assistant and graduate student. He assisted in teaching and research on the theory of electrical machinery. He was promoted to instructor in 1929, and received the S.M. degree in 1932. With the exception of two leaves of absence, he has remained at MIT as assistant professor and associate professor. He is co-author of two textbooks, "Magnetic Circuits and Transformers" (1943) and "Electric Machinery" (1952). During World War II, in addition to teaching, he was a research engineer at the Servomechanisms Laboratory, MIT, on the development of fire-control systems. In 1952, while on a 6-month leave of absence, he worked in the direct-current design section of the small and medium motor department at the River Works of General Electric Company, Lynn, Mass., principally on problems concerning amplidynes. During 1953-55, while again on leave of absence, he taught at Thayer School of Engineering, Dartmouth College, Hanover, N. H.,

Charles Kingsley, Jr.

and helped to establish a course and laboratory for teaching the theory of servomechanisms. In the Summer of 1954, he was at Boeing Airplane Company, Seattle, Wash., studying electric generating systems for large aircraft. He is a member of Tau Beta Pi, Eta Kappa Nu, and the American Society for Engineering Education. He has served as a member of the AIEE Electrical Machinery Committee (1935-38), Air Transportation Committee (1945-47), and Rotating Machinery Committee (1947-49). He has also served on the Synchronous Machinery Subcommittee (1935-47); and the Induction Machinery Subcommittee (1936-43, 1947-49).

* Mr. Kingsley's transfer to the grade of Fellow was approved at the Board of Directors meeting on June 26, 1959.

CORRECTION: On p. 964 of the September issue of *Electrical Engineering*, column 1, the position of W. A. Sumner was incorrectly listed. It should read: "assistant engineering manager, distribution transformer engineering, Westinghouse Electric Corporation."

AIEE PERSONALITIES

GE Research Laboratory
T. M. Linville

T. M. Linville (AM '27, F '47) of the General Electric (GE) Research Laboratory has been named a member of the National Research Council (NRC). Manager of the research operation department at the GE Research Laboratory, he will represent AIEE in the NRC's Division of Engineering and Industrial Research. His term will expire June 30, 1962. Mr. Linville joined GE in 1926 after graduation from the University of Virginia. He has specialized in design and development of motors and control systems, engineering administration, and engineering education. He has been appointed also as chairman of the Development Council for Science of Rensselaer Polytechnic Institute. Mr. Linville, who has been a director of the Institute, 1953-57, has served on the following AIEE Committees: Sections (1945-47, 1956-57); Rotating Machinery (1947-52); Education (1947-49, 1958-60, chairman 1958-59); Alfred Noble Prize Committee, ASCE (1948-53); Membership (vice-chair-

man District 1, 1950-51); Publication (1952-54); Board of Directors (1953-57); Public Relations (1953-57); Executive (1954-56); Finance (1954-57, chairman 1956-57); Engineers Joint Council representative (1954-57); Edison Medal (1955-57); General Applications Division (1956-59); Research (1957-60); Management (1957-59); Professional Development and Recognition Department (1958-59); Engineers' Council for Professional Development (1958-61); and Planning and Co-ordination (1959-60).

W. R. G. Baker (AM '19, F '47) has been appointed executive committee chairman of the board of directors of Gulton Industries, Inc. Dr. Baker, who is president of the Syracuse University Research Corporation and former vice-president of the General Electric Company, was elected to the board of the diversified electronics firm one year ago. He was chairman of the AIEE Electronics Committee (1945-47) and Communication and Science Co-ordinating Committee (1947-48).

Fred Benjamin (AM '53) has been appointed sales manager of the Industrial Division of Christie Electric Corporation, Los Angeles, Calif. Prior to his joining the Christie organization, Mr. Benjamin held positions as director of research and development at American Electronics and as director of sales and engineering at Magnetic Systems.

L. J. Besch (AM '47, M '55) has been appointed to the position of manager in the Transformer Division of Westinghouse Electric Corporation, Pittsburgh, Pa. Prior to his new appointment, he was supervisor of new plant engineering.

R. R. Bracchi (AM '45) has been appointed manager of the General Electric (GE) Louisville Apparatus Service Shop. He was formerly a maintenance repair specialist for GE in Portland, Oreg. He is a past chairman of the AIEE Portland Section. The appointment of **J. R. Crittenden, Jr.** (AM '57) as "severe environment specialist," a newly created position in GE's receiving tube department, Owensboro, Ky., has been announced. Since 1955, Mr. Crittenden has studied high temperature and nuclear radiation effects on electronic equipment in conjunction with work conducted by GE's aircraft nuclear propulsion department at Evendale, Ohio.

E. J. Brooks (AM '52) has joined the staff of the Argonne National Laboratory as an assistant electrical engineer in the Idaho Division, which is located at the National Reactor Testing Station near Idaho Falls, Idaho. Prior to joining Argonne, Mr. Brooks was an electrical engineer for the Naval Reactor Facility of the Westinghouse Electric Corporation at the National Reactor Testing Station.

H. R. Buttner (M '50), assistant engineer of Burndy Corporation, Norwalk, Conn., has been assigned to Burndy's European subsidiary, Burndy Electra S. A., for several months. Working from headquarters in Antwerp, Belgium, Mr. Buttner will train the company's representatives in European cities in the technical aspects of connector applications.

R. M. Casper (M '40), general manager of the Atomic Energy Division of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been elected vice-president of the company.

W. L. Cisler (M '35. F '47), president of the Detroit Edison Company, has been elected president of the American Society of Mechanical Engineers (ASME), and **H. N. Muller, Jr.** (AM '37, F '49), vice-president and chief engineer of Canadian Westinghouse Company, Ltd., Hamilton, Ont., was elected a vice-president of ASME. The new officers will begin their duties at the business meeting November 30, 1959, at ASME's annual meeting in Atlantic City, N. J. Mr. Cisler will serve for a 1-year term, and Mr. Muller for 2 years. Mr. Cisler served as chairman of the following AIEE committees: Power Generation (1940-42); and Management (1948-49). He is a member of the AIEE Edison Medal Committee (1956-61). Mr. Muller is a member of AIEE committees, as follows: Power Generation (1944-46, 1957-60); Publications (1952-60, vice-chairman 1959-60); and Members-for-Life Fund (1954-60, vice-chairman 1956-60). He served as chairman of the AIEE Education Committee (1950-52); Student Branches Committee (1948-49); and Charles LeFeyt Fortescue Fellowship (1949-50).

E. E. Combs (M '58) has been appointed vice-president, engineering, of the Lynch Carrier Telephone Systems, Inc., San Francisco, Calif. Prior to his advancement and since 1956, he was chief engineer. He is a member of the AIEE Wire Communication Systems Committee (1959-60).

A. E. Cooper (AM '50, M '59) has been promoted to manager of the Owego, N. Y., Engineering Laboratory, Federal Systems Division, International Business Machines Corporation (IBM). He had been manager of advanced systems research at the Owego facility. **R. E. LeDuc** (AM '52), formerly development engineer at the Owego facility of IBM, has been appointed project co-ordinator, technical co-ordination, Titan Project Office.

M. F. Corcoran (AM '52, M '59) has been transferred from his post as sales representative in the Cleveland, Ohio, district of Allis-Chalmers Manufacturing Company to application engineer in the electrical application department.

H. W. Curtis (AM '52), formerly engaged in research and teaching at Dartmouth College, has joined the International Business Machines Corporation (IBM) as an advisory engineer at the company's Federal Systems Division Laboratory at Kingston, N. Y. He will work on development of military tactical and logistics systems. **E. L. Gruenberg** (AM '50), who was manager of staff engineering at the W. L. Maxson Corporation, New York, N. Y., has recently been appointed manager of data acquisition projects at IBM's Federal Systems Division Laboratory at Kingston. Mr. Gruenberg's duties include management of the laboratory's space system data acquisition projects.

R. E. Deal (AM '49) has been appointed manager of marketing for the 3E Company, Melrose Park, Ill. He was formerly with the Line Material Industries of Atlanta, Ga., and the Power Company of Charlotte, N. C.

R. W. Deichert (AM '49) has been appointed engineering manager for scientific instruments of the Industrial Electronics Division at Allen B. Du Mont Laboratories, Inc. In his new post, Mr. Deichert will have over-all engineering and design responsibilities for the company's oscilloscopes and related electronic test equipment and accessories. Prior to his new appointment, he had been manager of the Data and Display Laboratory of Du Mont's Military Electronic Operations.

J. J. Dempsey (AM '41) was recently elected vice-president of Servomechanisms, Inc. (SMI) by its board of directors. He was appointed manager of SMI's Mecha-

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trol Division, Westbury, L. I., N. Y., in 1955 and will continue in this capacity.

J. A. De Veer (AM '51) has been promoted to staff engineer, exploratory reliability department, International Business Machines (IBM) product development laboratory, Poughkeepsie, N.Y. **G. E. Doody** (AM '50, M '59) of Vestal, was named staff engineer, mechanism development, at Federal Systems Division, IBM Owego, N.Y. **J. E. Tutty** (AM '53, M '59) has been appointed staff engineer amplifier circuits, Federal Systems Division, IBM Owego.

W. C. Dunlap, Jr. (M '51), director of semiconductor research in the Research Division of Raytheon Company, Waltham, Mass., has been named editor-in-chief of *Solid State Electronics*, a new international journal dealing with transistors and other solid-state devices. Dr. Dunlap will serve as the U.S. representative heading a five-man board of editors from the United Kingdom, Europe, the Far East, and one to be appointed from the USSR. He is a member of the AIEE Basic Sciences Committee (1951-60, chairman 1957-59); and Science and Electronics Division Committee (1957-60).

H. E. Edgerton (AM '27, F '46), professor of electrical measurements at the Massachusetts Institute of Technology, Cambridge, Mass., has received the Progress Medal Award of the Society of Motion Picture and Television Engineers. Dr. Edgerton is chairman of the board and vice-president of Edgerton, Germeshausen and Grier, Boston, Mass.

Harvey Fletcher (M '23, F '30, Member for Life), director of research and dean at Brigham Young University, Provo, Utah, was made an honorary member of the Society of Motion Picture and Television Engineers (SMPTE). Dr. Fletcher was cited as a "pioneer in modern psychoacoustics" who has "bridged the chasm between physics and psychology leaving such permanent spans as the relation between frequency, intensity, and loudness (the Fletcher-Munson curves), the subjective loudness scale, and concepts of masking." Dr. Fletcher is the 10th living honorary member of SMPTE. He has served on the AIEE Application of Electricity to Therapeutics Committee (1941-42).

P. G. Fredericks (M '29), a veteran of almost half a century in the electrical industry, has retired from his position as commercial vice-president of Federal Pacific Electric Company, New York, N.Y.

A. E. Frost (AM '27, M '54) has been appointed director of planning—plant and systems—of the Western Union Telegraph Company. He was new methods planning engineer since 1955, after he had served as equipment research engineer. He has served on the following AIEE Committees: Communication (1948-49); Communication Switching Systems (1949-57, chairman 1953-55); Communication Division (1953-55, 1957-60); Telegraph Systems (1955-56); Automation and Data Processing (1956-59); Data Communication (1957-60, chairman 1958-59); and Educational Publications (1959-60).

Appointments to key management positions at the New York Shipbuilding Corporation (Ship) have been announced. **E. A. Geary** (AM '27, M '34), who has served the Merritt-Chapman & Scott subsidiary as chief electrical engineer for the last 10 years, has been advanced to the post of director of engineering. Mr. Geary is a member of the AIEE Marine Transportation Committee (1950-60). **E. F. Blinn** (AM 27, M '52), who joined Ship in 1934, succeeds Mr. Geary as chief electrical engineer.

Kenneth Goodman (AM '50) has been appointed chief engineer of Engineered Electronics Company, Santa Ana, Calif. Mr. Goodman left a post as chief customer engineer of Helipot Division of Beckman Instruments, Fullerton, Calif. Engineered Electronics is a subsidiary of Electronic Engineering Company of California, also located in Santa Ana.

G. J. Gross (AM '30, M '47) was recently appointed utilities engineer in the Regional Office of the U. S. Bureau of Public Roads, Hagerstown, Md. The region comprises the District of Columbia, and the States of Delaware, Maryland, Ohio, Pennsylvania, Virginia, and West Virginia.

Melpar, Inc., a subsidiary of Westinghouse Air Brake Company, Falls Church, Va., has announced the following promotions: **E. S. Hall** (AM '37, M '48) has been named section head, and **W. G. Heffron, Jr.** (AM '48, M '56) has been advanced to the post of section head in the simulation and training systems engineering department. Mr. Heffron has served on the AIEE Computing Devices Committee (1956-59).

J. B. Hodtum (AM '21, F '49, Member for Life), manager of the central station engineering department, Allis-Chalmers Manufacturing Company (A-C) Works in Pittsburgh, Pa., retired recently after more than 35 years of service. Mr. Hodtum began working for A-C in 1924 as a sales engineer. In 1947, he was given the position which he held until his retirement. He has served on the following AIEE Committees: Transmission and Distribution (1940-50); Electrochemistry and Electrometallurgy (1943-46, 1949-50); Transformers (1947-58, chairman 1949-51); System Engineering (1947-49); Electric Heating (1947-49); Standards (1949-50); Technical Program (1949-50); and Power Division (1949-51).

Alois Hoefle (M '46, F '57), chief electrical engineer of the Toledo Edison Company, Toledo, Ohio, was appointed administrative vice-president at a meeting of the company's board of directors. **C. E. Flahie** (AM '45, M '51), transmission and distribution engineer, was named to succeed Mr. Hoefle as chief electrical engineer.

R. M. King (AM '59) has been advanced to associate engineer in the Advanced Systems Development Division of International Business Machines, Inc. (IBM) at Poughkeepsie, N. Y. He is engaged in *305* Diagnostics, RAMAC–*705* System, and systems design for an Advanced Disk File Control Unit, *7090* System, to be used in an airline reservation system. He started with the company in 1958 as a junior engineer in logical design of the RAMAC–*705*.

Joseph Kukel (AM '54) has been appointed chief engineer, instruments and systems, of Daystrom Pacific Division of Daystrom, Inc., Los Angeles, Calif. Dr. Kukel was formerly chief engineer for advance development at Daystrom Pacific.

F. R. Lack (M '37, F '48), electronics engineer and executive, was elected a director of the Sprague Electric Company, North Adams, Mass., by its board of directors. Mr. Lack served on the AIEE Communication Committee (1938-41).

Marvin Lee (AM '35, M '41), formerly executive vice-president of Burndy Corporation, Norwalk, Conn., has been elected its president. He succeeds **Bern Dibner** (AM '23, F '42, Member for Life), who was elected chairman of the board of directors.

W. D. Leonard (AM '56) has joined Philco Corporation's Government and Industrial Division as manager of communication sales. He was formerly manager of the government and industrial sales department at Lenkurt Electric Company, Inc.

I. S. Lerner (AM '49) has been appointed applied research director for Royal McBee Corporation. For the last 3 years, he has directed business machines research at Instrument Development Laboratories, Inc., Royal McBee subsidiary located in Attleboro, Mass.

R. A. Lombard (AM '48) has been appointed sales manager of the Langevin Division of the W. L. Maxson Corporation, New York, N. Y.

H. W. Luce (AM '50, M '58) has been named an application engineer for lightning arrestors in the protection equipment department of Hubbard and Company, Chicago, Ill. New field assignments as Hubbard apparatus engineers include: **Sidney Friend, Jr.** (AM '50), Northeast Division, and **J. H. Rusk** (AM '54), Midwest Division.

L. C. Marshall (AM '38, M '47) has been named associate technical director of the Microwave Power Laboratory of Varo Manufacturing Company, Inc., Garland, Texas. He was previously director of research of the Link Belt Company. He served on the AIEE Nucleonics Committee (1950-54).

W. G. Martin III (AM '41, M '47) has been named assistant chief engineer of the Emerson Electric Manufacturing Company, St. Louis, Mo. His responsibilities include supervision of the specifications and drafting groups and the Electrical Division's engineering laboratory.

R. W. Matthews (AM '55) has been appointed chief engineer of National Pneumatic Company, Inc., and its Holtzer-Cabot Division, Boston, Mass. Mr. Matthews, who has been engaged in motor design since he joined the company 19 years ago, now directs an intensive expansion program in the motor and telephone engineering sections, each concerned with product design, development, and manufacture.

M. M. McIntire (M '47), who is now an independent consulting engineer in San Pablo, Calif., received the Department of Interior's Distinguished Service Award upon his retirement from Government service recently. Mr. McIntire was cited for having served more than 26 years with the Bureau of Reclamation in electrical and hydraulic engineering, including service with the U. S. Army.

I. A. Mitchell (AM '31), president of the United Transformer Corporation, New York, N. Y., has been named chairman of the Inductive Components Subdivision of the Parts Division of Electronic Industries Association (EIA), Washington, D. C. **A. W. Dawson** (AM '49), manager of the industrial bulk sales department, Corning Glass Works, Corning, N. Y., has been given the position of chairman of the Printed and Modular Components Subdivision of the Parts Division. This division was reorganized at the EIA Fall Conference.

M. E. Mohr (AM '39, M '53), vice-president of engineering for Ramo-Wooldridge, a division of Thompson Ramo Wooldridge Inc., Los Angeles, Calif., was awarded an honorary doctor of engineering degree by the University of Nebraska at its 88th annual commencement for his civic and industrial leadership. Dr. Mohr's engineering contributions include research and development on telephone transmission and switching, and the application of electronic devices to telephone switching. He was a pioneer in his work on germanium diodes, transistors, and gas tubes. Dr. Mohr received his B.S. degree in electrical engineering from the University of Nebraska in 1938. He served on the AIEE Computing Devices Committee (1953-55).

N. W. Morelli (AM '52) has been appointed works manager of the Allis-Chalmers Manufacturing Company (A-C) Works in Pittsburgh, Pa. He had been superintendent of transformer assembly at the A-C Terre Haute, Ind., Works. **Z. A. Wachta** (AM '58) has been named to the Development Engineering Section, Boston, Mass., Works, of the A-C Power Equipment Division. Mr. Wachta is a graduate electrical engineer of the University of Massachusetts and recently completed the A-C training course for graduate engineers.

R. E. Morris (AM '58) has been appointed field service engineering representative for the Apparatus Division of Texas Instruments, Inc., to serve the northwestern U. S. His headquarters will be in Seattle, Wash. Before joining Texas Instruments, he served as Northwest District sales manager for the Jack and Heintz Company.

W. F. Newbold (M '58) has been appointed director of research for the Brown Instruments Division of Minneapolis-Honeywell Regulator Company. He succeeds **W P. Wills** (M '42), director since 1955, who has been named technical advisor to the director of engineering, a new post. Mr. Wills has served on the AIEE Electronic and High Frequency Instruments Committee (1956-58), Recording and Controlling Instrumentation Committee (chairman 1956-59), Instrumentation Division Committee (1956-59), and Joint Division Committee on Automation and Data Processing (1956-58).

K. A. Norton (AM '41, F '56), chief of the Radio Propagation Engineering Division of the Boulder Laboratories, National Bureau of Standards, will receive the Harry Diamond Memorial Award during the 1960 annual convention of the Institute of Radio Engineers in New York next March. This award is presented annually to a person in Government service in the field of radio or electronics for outstanding contributions as indicated by publication in scientific journals. Mr. Norton was cited "for contributions to the understanding of radio wave propagation." He has served on the AIEE Television and Aural Broadcasting Systems Committee (1955-60).

W. S. Osborne (AM '42, M '49) has been appointed to the newly created position of plant engineer at Lincoln University. He is in charge of all new construction design and is responsible for all mechanical and electrical maintenance.

A. W. Peabody (AM '37) has been appointed supervising engineer of the corrosion engineering group of Ebasco Services Inc., New York, N. Y. Since 1939, he has concentrated on a wide variety of corrosion engineering projects for many utility and industrial companies.

P. F. Pittman (AM '57) has been appointed manager of the solid state electronics application section of the materials engineering departments, Westinghouse Electric Corporation, East Pittsburgh, Pa.

D. W. Pugsley (AM '36, M '56), who recently joined the technical staff of Ramo-Wooldridge, a division of Thompson Ramo Wooldridge Inc., has been appointed to organize and manage a department on display techniques within the Engineering Division. He served on the AIEE Television Broadcasting Systems Committee (1949-50). **R. A. Koster** (AM '54), electrical engineer, has joined the reconnaissance systems department of the Ramo-Wooldridge Division.

L. M. Robertson (AM '27, F '45), formerly chief electrical engineer, has been appointed manager of engineering of the Public Service Company of Colorado, Denver, Colo. Four divisions—electrical, mechanical, and structural engineering, and right-of-way procurement—will report to Mr. Robertson in his new position. Mr. Robertson is an AIEE director (1956-60) and former vice-president (1945-47). He is serving on the following AIEE committees: Transmission and Distribution (1942-60); Professional Conduct (1957-60); and Constitution and Bylaws (1959-60).

F. A. Rojak (AM '49) has been assigned to the department of electronic engineering of Lowell Technological Institute, Lowell, Mass., as assistant professor. Holder of the B.S.E.E. from Pratt Institute, Mr. Rojak most recently was project engineer in electronic design and development for the National Company.

J. F. Sullivan (AM '57) has been appointed assistant professor in the department of general and textile engineering at Lowell. Mr. Sullivan, who was formerly assistant professor at Merrimack College, received the B.S.E.E. degree at Catholic University and has had several years' industrial experience.

G. N. Rosa (AM '48) has been elected a member of the board of directors of Statham Instruments, Inc., Los Angeles, Calif. He retains his post as vice-president for marketing.

P. N. Ross (AM '45), veteran of 20 years' service for the Westinghouse Electric Corporation, has been appointed general manager of the Bettis Atomic Power Laboratory which the company operates for the U. S. Atomic Energy Commission. He has served on the AIEE Nucleonics Committee (1949-59, chairman 1956-58), and Science and Electronics Division Committee (1956-59).

H. O. Rost (M '58), formerly of the Radio Corporation of America, has recently been appointed manager of tactical and logistic systems at the International Business Machines Corporation (IBM) Federal Systems Division Laboratory at Kingston, N. Y. Dr. Rost's responsibilities include the supervision of the development of computers for military tactical and logistics systems. **W. R. Smith,** who was previously with the American Telephone & Telegraph Company, has joined IBM as an advisory engineer at the Federal Systems Division Laboratory at Kingston. Mr. Smith was assigned to systems analysis for military tactical and logistics systems.

J. M. Salzer (AM '51, M '58) has joined the technical staff of the engineering vice-president, Ramo-Wooldridge, division of Thompson Ramo Wooldridge Inc. Dr. Salzer was formerly director of systems at the Magnavox Research Laboratory. **S. Z. Gunter** (AM '57), formerly junior engineer at International Business Machines Corporation, Poughkeepsie, N. Y., has joined the staff of Thompson-Ramo-Wooldridge (TRW) Products Company. **F. C. Mears** (AM '53) has joined TRW Products as a project engineer.

E. S. Schapiro (AM '48) has joined Control Electronics Company (CEC), Huntington Station, N. Y., as supervisor of CEC's filter engineering department. In her new position, Mrs. Schapiro is responsible for the design, development, and production of all audio and high-frequency filters. For the last 3 years, Mrs. Schapiro was a project leader at Avien Inc., Woodside, N. Y., where she worked

on solid-state devices and transistorized aircraft instruments.

J. J. Sedlacek (AM '51) has been named manager of the Philadelphia district sales office of I-T-E Circuit Breaker Company, Philadelphia, Pa. Former district manager of I-T-E's Minneapolis, Minn., sales office, Mr. Sedlacek replaces **M. L. Stoughton** (AM '43, M '49), who has been appointed to carry out special engineering promotion for the company's Kelman Power Circuit Breaker Division, Los Angeles, Calif. Mr. Stoughton served on the AIEE Public Relations Committee (1953-58).

Samuel Seely (AM '38, M '44), head of the department of electrical engineering at Case Institute of Technology, has been awarded a Fulbright Lectureship to the Polytechnic University of Athens, Greece. Dr. Seely will remain in Greece for a year on leave of absence from Case. He served on the AIEE Education Committee (1957-58).

F. B. Silsbee (AM '13, F '42, Member for Life) retired July 31 as chief of the Electricity and Electronics Division of the National Bureau of Standards (NBS) after 48 years of service. Appointed division chief in 1946, Dr. Silsbee directed the work of NBS laboratories responsible for establishment and maintenance of basic electrical units; testing standard electrical apparatus and instruments used in science and industry; development of new methods for measuring electrical quantities; determination of electrical, magnetic, and electrochemical properties of a wide range of materials; and development and testing of electronic devices and components. He served on the AIEE Standards Committee (1941-43, 1945-59); Technical Program Committee (1941-43); Research Committee (1939-45); Instruments and Measurements Committee (1939-46, 1948-55, chairman 1941-43); Electrophysics Committee (1922-24); and Joint Power Factor Committee (1920-21).

W. D. Sinclair (AM '42, M '51) has joined Kaiser Engineers Division of Henry J. Kaiser Company as a power consultant. His assignment includes development activities in the power field, with emphasis on utilities of medium size.

C. H. Singer (M '50), vice-president of operations, Eastern Division, Page Communications Engineers, Inc., a subsidiary of the Northrop Corporation, Washington, D. C., has been named vice-president and director of the maintenance and operations department.

R. G. Slauer (AM '41, M '48), manager of marketing services, Fixture Division, Sylvania Electric Products Inc., Wheeling, W. Va., continues to serve as vice-president of the Illuminating Engineering Society (IES). This is the second year of his 2-year term. **J. S. Hamel** (M '48), consulting electrical and mechanical engineer, Glendale, Calif., is a newly-elected director. **J. B. Deck, Jr.** (AM '48, M '57), lighting engineer, Texas Power and Light Company, Dallas, Texas, is the new vice-president of the southwestern region.

G. J. Taylor (M '44, F '58), vice-president for research and development, Day-Brite Lighting, Inc., New York, has been president of the IES since October 1958. Mr. Slauer has served on the AIEE Production and Application of Light Committee (1946, 1949-50).

J. J. Sousa (AM '43) has been advanced to the post of chief engineer of the Electric Specialty Company, Stamford, Conn. He was formerly chief electrical engineer.

Members of the Spectrum Committee of the Electronic Industries Association (EIA), Washington, D. C., which met during the EIA Fall Conference, included: **R. C. Sprague** (M '40, F '49), chairman of the board and treasurer of the Sprague Electric Company, North Adams, Mass., who is vice-chairman of the EIA Spectrum Committee; **D. G. Fink** (M '45, F '51), research director of Philco Corporation, Philadelphia, Pa.; **I. J. Kaar** (M '44, F '51), Hoffman Electronics Corporation; **D. B. Smith** (AM '35, F '55), vice-president, Philco Corporation; **W. R. G. Baker** (AM '19, F '47), Syracuse University Research Corporation, as ex officio member; and **L. G. Cumming** (M '47), technical secretary of the Institute of Radio Engineers, New York, N. Y., as ex officio member.

Carroll Stansbury (M '35, F '38) of the Electronic Instrumentation Section, National Bureau of Standards, has received the U. S. Department of Commerce Silver Medal for Meritorious Service. Mr. Stansbury was cited for "many important contributions in the development of complex electronic and electromechanical equipment," and for "outstanding administrative services during a major redeployment of a large group of technical specialists." He has served on the following AIEE Committees: Electric Welding (1937-39), Marine Transportation (1945-56), Instruments and Measurements (1951-55), and Special Instruments and Auxiliary Apparatus (1956-60).

G. V. Stanton (AM '49) recently joined the technical staff of Ramo-Wooldridge, a division of Thompson Ramo Wooldridge Inc. He is attached to the systems technology division. **H. J. McCreary** (AM '24, F '46), formerly senior project engineer at General Telephone Laboratories, has joined the Ramo-Wooldridge Division. Mr. McCreary served on the AIEE Electronics Committee (1953-57) and Surveys Committee (1957-58).

H. M. Stewart (AM '33, M '38), engineering associate in the Technical Division of Humble Oil & Refining Company's Baytown, Texas, refinery, has retired under the company's special retirement plan. He started with Humble in 1930, has served as a project engineer and as head of the Mechanical Engineering Division. As engineering associate, he was responsible for evaluating the refinery's power and steam needs and for recommending the building of additional generating capacity when needed. He has served on the AIEE Petroleum Industry Committee (1955-58, chairman 1958-59), and Industry Division Committee (1958-59).

M. L. Stoughton (AM '43, M '49) has been appointed to a new position as national sales specialist for the outdoor power circuit breakers manufactured by the I-T-E Circuit Breaker Company's Kelman Division, Los Angeles, Calif. Mr. Stoughton was formerly manager of I-T-E's Philadelphia, Pa., district office. He served on the AIEE Public Relations Committee (1953-58).

A. H. Taylor (AM '19, F '46) of Claremont, Calif., received a Stuart Ballantine Medal from the Franklin Institute, Philadelphia, Pa., for his research in radio communications during the last half-century. The medal citation to Dr. Taylor reads: "For his more than 50 years of scientific work, which contributed notable advances in the technology of radio communications, particularly in the fields of radio wave propagation and of reliable communications systems." He held the position of chief consultant in electronics at the Naval Research Laboratory, Washington, D. C., until his retirement in 1948.

Ragnar Thorensen (AM '46) has been appointed general manager of Magnavox Research Laboratories, Fort Wayne, Ind. Dr. Thorensen has been director of research since the inception of the laboratories in 1953 at Los Angeles, Calif.

J. A. Tucker (M '51, M '56), assistant to the department head, electrical engineering department, Massachusetts Institute of Technology, Cambridge, Mass., has been elected to the national board of directors of the Eta Kappa Nu Association, electrical engineering honorary society. He served as president of the Boston Alumni Chapter of this society during 1953-54 and has been on its advisory board since. Mr. Tucker is serving a second term as member of the Executive Committee, Boston Section AIEE, and has served on two national AIEE committees, Special Publications (1957-60), and Student Branches (1957-60).

J. C. Van Arsdell, Jr. (AM '46), has been appointed sales manager and assistant to vice-president of Sage Electronics Corporation, East Rochester, N. Y. He came to Sage from Erie Resistor Corporation, Erie, Pa.

R. I. Van Nice (AM '50) has been chosen as the 21st recipient of the Benjamin Garver Lamme graduate scholarship. The award will allow him to return to Carnegie Institute of Technology on a full-time basis to complete all requirements for his doctorate. Westinghouse Electric Corporation has awarded the graduate scholarship for a year of advanced study to an engineer at its new products engineering department. The Lamme scholar is informally considered to be the corporation's outstanding young engineer of the year. So far, 20 Westinghouse engineers who were considered exceptionally able have been granted scholarships to continue advanced study on a full-time basis at universities in this country and abroad.

S. N. Vavoudis (AM '52), formerly of General Precision Laboratories, has been appointed director of engineering of Itemlab, Inc., Port Washington, N. Y.

L. G. Walker (AM '53, M '53) has joined the Equipment and Systems Division of Raytheon Company, Waltham, Mass., as manager of the communication and control systems department, a newly created post. Mr. Walker was formerly with Motorola, where he was employed successively as chief engineer of carrier and control, manager of power utility products, and, for the last 4 years, as marketing manager for microwave and industrial controls. He served on the AIEE Power System Communications Committee (1953-59).

A. H. Waynick (M '55), director of the Ionosphere Research Laboratory, Pennsylvania State University, University Park, Pa., has been named to the Advisory Panel on Atmospheric Sciences of the National Science Foundation, Washington, D. C. He has served on the AIEE Electronic and High-Frequency Instruments Committee (1956-60).

B. C. West (AM '39, M '46), formerly assistant to the western regional manager and district sales manager for Federal Pacific Electric Company at San Francisco, Calif., has been named general sales manager for Mears Electric Circuit Breakers, Inc., of Portland, Oreg.

H. A. Wheeler (F '46), president of Wheeler Laboratories, Inc., has been elected a vice-president and director of Hazeltine Corporation, Little Neck, N. Y. He served on the AIEE Board of Examiners (1952-54).

H. B. Whitaker (AM '37, M '51) has been advanced to vice-president and chief electrical engineer of the Underwriters' Laboratories, Inc., New York, N. Y. He was formerly executive engineer. He has served on the following AIEE Committees: Safety (1951-60, chairman 1955-57); Technical Operations (1955-57); and National Fire Waste Council Representative (1955-57).

D. G. Wilson (AM '40, M '49), has been appointed assistant vice-president of the Electronics Division of Stromberg-Carlson, a division of General Dynamics Corporation. Dr. Wilson, who was formerly general manager of Stromberg-Carlson—San Diego, will continue to make his headquarters in San Diego, Calif. He has served on the following AIEE committees: Electronics (1949-60, chairman 1957-59); Instruments and Measurements (1953-55); Special Instruments and Auxiliary Apparatus (1956-57); Science and Electronics Division (1957-60); Education (1958-60); Registration of Engineers (1958-60); Electrical Techniques in Medicine and Biology (1958-59); and Research (1958-60).

O. H. Winther (AM '48) has been promoted to maintenance superintendent of the Minnesota Mining and Manufacturing Company, St. Paul, Minn. He had been assistant maintenance superintendent.

OBITUARIES

Norwood Blankenship (M '46), manager of intermediate distribution sales in the central territory, Southwestern District, General Electric Company (GE), Dallas, Texas, died recently. He was born November 15, 1912, in Dallas. He received the B.S.M.E. degree in 1936 from Southern Methodist University. After graduation, he took the GE test course at Schenectady, N. Y. In September 1937, he was assigned to quality engineering at the Fractional Horsepower (FHP) Motor Design Engineering Division, Fort Wayne, Ind. Here he worked with the manufacturing organization to maintain engineering standards of production, and to test and approve substitute materials and correct deficiencies in either manufacturing or engineering. For one year of this time, he was responsible for the electrical design of FHP motors for fan application. In December 1938, he was transferred to the FHP Motor General Office Division. He was assigned responsibility for the field test of FHP motors on customer apparatus, and recommendation of suitable electrical and mechanical components for the motors powering this equipment. In 1945, he was transferred to the Dallas office.

John William Carpenter (M '35, F '46), who was regarded as dean of the electrical industry in the Southwest, died recently at his home in Dallas, Texas. He was born August 31, 1881, near Corsicana, Texas. In 1905-06, he spent 2 years in the testing department of the General Electric Company, Schenectady, N. Y. He received the honorary degree of doctor of engineering in 1945 from Southern Methodist University, Dallas, for his achievements in developing the natural resources of Texas and establishing the steel industry in East Texas. Mr. Carpenter was instrumental in the establishment of Texas Technological College at Lubbock, serving on its first board of regents, and was accorded an L.L.D. degree from the college. Since 1907, he held executive positions in the Corsicana Gas and Electric Company, Texas Power and Light Company, Dallas Railway and Terminal Company, Texas Electric Service Company, Texas Public Utilities Corporation, New Mexico Electric Service Company, Texas Refrigeration and Ice Company, and Texas Utilities Company. Mr. Carpenter envisioned and constructed the large steam electric generating station of the Texas Power and Light Company at Trinidad, Texas, and the utilization of the large lignite deposits nearby, as well as the vast network of transmission lines which integrated the scattered electric utility properties through an area of 52 counties in North Central and East Texas. The Lone Star Steel Company was organized by Mr. Carpenter, who developed the general plan for an engineering project which was constructed by the Defense Plants Corporation at a cost of approximately $30 million.

Jere Shunk Cave (AM '28, M '32, Member for Life), assistant general manager, Gustav Hirsch Organization, Columbus, Ohio, died recently. He was born August 18, 1887, in Mansfield, Ohio, graduated from Mansfield High School, and attended Ohio State University for one year. During 1906-19, he was employed by Bell Telephone Company in Ohio as switchboard installer, switchboard maintenance man, wire chief, equipment superintendent, plant superintendent, and assistant equipment engineer. In 1919-23, he was superintendent for Mansfield Telephone Company. During 1923-27, he conducted his own business. In February 1927, he was employed as an engineer by Snook, Martin and Company, Columbus. In 1929, he was an engineer for the Standard Public Service Company, Columbus, and, in 1931, he was employed as chief engineer by the Venezuela Telephone Company, Caracas, Venezuela. He had recently been appointed to the AIEE Management Committee.

Henry Woodman Clark (M '34, F '48), an engineer for the Potomac Electric Power Company for more than 40 years until his retirement 3 years ago, died recently at the age of 69. He was born June 23, 1890, in Washington, D. C., and graduated in 1913 from the University of Virginia with a degree in electrical engineering. As assistant engineer of distribution for the electric power company, he was responsible for the engineering design of the transmission and distribution system, with particular reference to underground. As a result of his investigations, a number of improved types of underground cable, and low-voltage, high-voltage, street-light, and aerial cables were adopted. Mr. Clark was a first lieutenant in the Army Engineers in World War I and was awarded the French Croix de Guerre. He was a past president of the Washington, D. C., Society of Professional Engineers. He served on the AIEE Insulated Conductors Committee (1947-57) and Power Transmission and Distribution Committee (1939-47).

Winfield Hartley Fellows (AM '19, Member for Life), superintendent of the meter department of the Potomac Electric Power Company, Washington, D. C., from 1901 until his retirement in 1940, died recently at the age of 83. He was born November 9, 1875, in Scranton, Pa., and graduated from Lafayette College in 1897 with an electrical engineering degree.

Robert W. McChesney (AM '20, M '28), electrical contractor of Washington, D. C., died recently. He was born May 22, 1891, in Washington, D. C. His firm, Harry Alexander, Inc., which he sold this year, had installed electrical systems for the Pentagon, the Bethesda Naval Medical Center, and the White House and Capitol wings. Mr. McChesney had been president and part owner of the firm since 1929, when he bought the business from its New York owners. He had joined it in 1919 as Washington manager. Long active in labor relations, he was recognized for revamping the Industrial Relations Council of the National Electrical Contractors Association and directing it during 1942-54. Mr. McChesney was president of the association for 10 years, and, since 1939,

the first year of his presidency, the electrical contracting industry had not had an authorized strike.

Harold Pender (AM '06, M '10, F 14, Member for Life), professor emeritus of the Moore School of Electrical Engineering at the University of Pennsylvania, Philadelphia, Pa., died recently at the age of 80. He was born January 13, 1879, in Tarboro, N. C. He received A.B. and Ph.D. degrees in 1898 and 1901, respectively, from Johns Hopkins University. In 1903, on special invitation of the university authorities at the Sorbonne, Paris, France, he established beyond question the existence of a magnetic field around a moving electrically charged body. An electrical engineer, author, and teacher, Dr. Pender was the first dean of the Moore School of Electrical Engineering. When the school was opened in 1923, he received an honorary D.Sc. degree. He had been professor-in-charge of the electrical engineering department at the university since 1914. Upon retirement in 1949, he became professor emeritus. Before he came to the university, Dr. Pender had been a professor at the Massachusetts Institute of Technology (MIT), where he taught theoretical and applied electricity and electrical engineering, and was director of the Research Division of the electrical engineering department. He was also an engineer for industrial concerns and had written several books on electricity and electromagnetism. He was a fellow of the American Academy of Sciences, a member of the Society for the Promotion of Engineering Education, and a member of the U. S. Committee of the International Electrotechnical Commission. He had been official delegate to the Third World Power Conference in Washington, D. C., in 1936; to the Faraday Centenary in London in 1931; and to the International Congress of Electricity in St. Louis, Mo., in 1904. Dr. Pender had served on the following AIEE Committees: Edison Medal (1916-19, 1945-50); Editing (1915-16); Executive (1917-19); Instruments and Measurements (1918-19); Publication (1919-20); Standards (1915-19, 1921-26, chairman 1921-23); Transmission and Distribution (1914-15); Library Board, United Engineering Trustees (1915-17); American Engineering Standards Committee (1922-24); U. S. National Committee, International Electrotechnical Commission (1922-23, 1929-32); Research (1923-27); Education (1924-28, chairman 1924-26); Electrophysics (1924-26); and Popular Science Award (chairman 1933-34).

Frank J. Petura (AM '07, M '12, F '31, Member for Life), retired, of Tangerine, Fla., died recently. He was born October 29, 1881, in Racine, Wis. In 1904, he graduated from the University of Wisconsin where he took an electrical engineering course. He was assistant engineer of the Lincoln Gas and Electric Light Company, Lincoln, Nebr., in 1904-05. The following year, he was instructor of electrical engineering in the University of Wisconsin. In 1906, he re-entered the Doherty organization, of which the Lincoln company was a member, and became the assistant to the secretary of the Doherty School of Practice at the Denver Gas and Electric Light Company. He was transferred to New York City in 1909 to work as electrical and gas engineer and purchasing agent for H. L. Doherty and Company. He was assigned to general engineering and report work. During 1909-10, he was engineer of the Spokane Falls Gas Light Company. He returned to New York in 1910 to act in an engineering capacity on construction, examinations, valuations, and purchases. In 1913, he became general purchasing engineer in general charge of purchases of subsidiaries of Cities Service Company, including standardization of equipment.

Elmer W. Johnson (AM '18, M '54, Member for Life), professor and assistant dean of the University of Minnesota's Institute of Technology, died recently. Born January 11, 1892, in Minneapolis, Minn., Prof. Johnson received his B.S. degree in 1914, E.E. degree in 1915, and M.E degree in 1923, all from the University of Minnesota. In 1915-16, he took the student training course at the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and later worked for the Northern States Power Company, Minneapolis, Minn. This was followed, in 1917-18, with service in the U. S. Army Engineers Corps in France. He became an instructor at the University of Minnesota in 1920, and was promoted subsequently to professor and assistant dean.

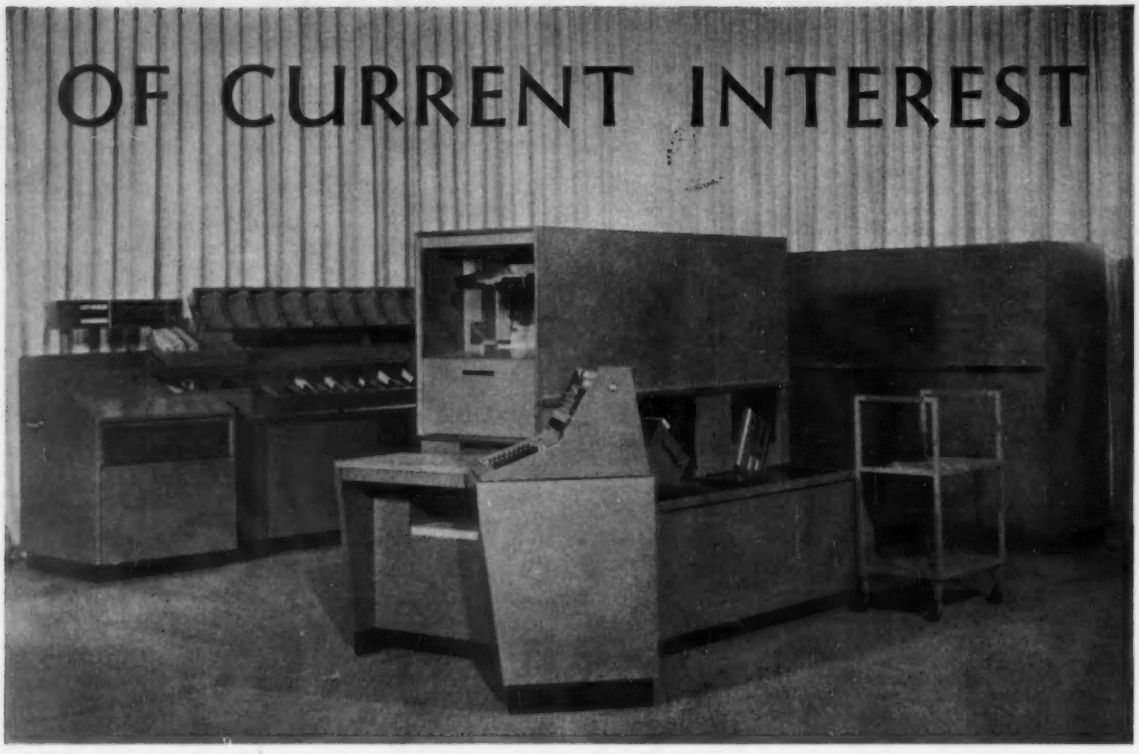
Arthur Bessey Smith (AM '04, M '13, F '22, Member for Life), electrical engineer of Evanston, Ill., died recently. He was born August 10, 1875, in Altoona, Iowa, and was educated at the University of Nebraska, Lincoln, Nebr., where he received the B.S. in electrical engineering in 1901. He received the electrical engineering degree in 1907 from Purdue University, LaFayette, Ind. In 1901-05, he operated telephone plants in Iowa, Nebraska, and New York. He was in charge of the department of telephone engineering, Purdue University, in 1905-09. He was assistant sales manager of the Automatic Electric Company, Chicago, Ill., in 1909-10, and later was research engineer in charge of the company. Mr. Smith served on the AIEE Standards Committee (1918-22); Communication Committee (1918-23, 1937-49); Communication Switching Committee (1949-55); Wire Communication Systems Committee (1949-53); and Award of Institute Prizes Committee (1950-52).

Jack Thomas Steppe, Jr. (AM '49), division commercial manager of the South Carolina Electric and Gas Company, Columbia, S. C., died recently at the age of 47. Mr. Steppe was born August 1, 1912, in Albemarle, N. C., and graduated from Clemson College in 1934 with a B.S. degree in electrical engineering. In 1935-39, he was turbine and switchboard operator of the Hydroelectric Power Plant, South Carolina Electric and Gas Company, Lake Murray, S. C. During 1939-47, he was system load dispatcher for the company at Columbia, and, in 1947, became assistant division superintendent of the company at Columbia. He served as chairman of the Columbia Subsection AIEE in 1953-54 and as chairman of the South Carolina Section in 1957-58.

Neander Woods Wade (AM '46), secretary of the Memphis Light, Gas, and Water Division, Memphis, Tenn., died recently. Mr. Wade was born March 19, 1899, in Memphis. In 1922, he was employed by the Board of Water Commissioners of the City of Memphis to make a study of stores inventory and cost accounting. He was transferred in 1923 to the accounting department, and put in charge of general accounting. As assistant to the secretary from 1926 to 1935, he was in active charge of financial affairs, accounting, and administrative work of the Memphis Light, Gas, and Water Division, and its predecessor company. In 1935, he was appointed secretary to the board, and functioned as treasurer, financial officer, and director of accounting and business administration. He held this position until he was appointed vice-president in January 1959. He negotiated the City of Memphis Electric Light Plant Revenue Bond, Series A, issue for $163 million, and had been active in affairs relating to the construction of the Thomas H. Allen Electric Generating Station.

Samuel Shelton Watkins (AM '07, M '26, F '46, Member for Life), electrical engineer associated with Gibbs and Hill, Inc., consulting engineers, New York, N. Y., until his retirement, died recently at the age of 74. He was born September 17, 1885, in Owensboro, Ky., and graduated in 1906 from Columbia University with a degree in electrical engineering. Mr. Watkins had been with Gibbs and Hill since 1920. He was responsible for the electrical design of power facilities for electrification of several railroads, notably the Pennsylvania Railroad's electrification from New York to Washington and Harrisburg, as well as electrical distribution systems of the Quonset Point, R. I., Naval Air Station and the Rome, N. Y., Air Depot. He was in charge of electrical engineering and design of the following projects: Woodmont Capacitor Station and bus changes at Cos Cob Power Plant for New York, New Haven and Hartford Railroad Company; Lake Charles, La., Power Plant of Cities Service Refining Company; Dille Bottom Power Plant of Ohio River Power Company; Bridgeport and New Haven tie-line substations and extensions to Bridgeport distribution system for United Illuminating Company; addition of 35,000-kw generating unit to the Harding Street Station of the Indianapolis Power and Light Company; and change to 60-cycle frequency and remote control of the Minetto Hydro-Electric Plant of the Northern New York Power Corporation. He had charge also of electrical design of substations and power stations for the following: Bay Ridge Improvement of New York Connecting and Long Island Railroad; Norfolk and Western Railway electrical zone extensions; Babylon Extension of electrification of Long Island Railroad. In 1917-20, he was employed by the Interborough Rapid Transit Company, New York, N. Y., as engineer in charge of electrical design and construction of additions to the 59th Street Power Station. Mr. Watkins had served on the AIEE Board of Examiners Committee (1948-60) and Protective Devices (1947-53) Committee.

OF CURRENT INTEREST



Visible Record Computer

Designed for the Banking Industry

▲ *Over-all view of Burroughs* B251 *Visible Record Computer—solid-state electronic data-processing system—shows how compact design is possible through use of new design and production techniques. All four units of the system seen here are: (1) high-speed check sorter* (left), *(2) cabinet housing computer* (right, background), *(3) processor* (center), *and (4) control console* (front, center).

PIONEERING a new concept in electronic data-processing systems, Burroughs Corporation has announced a high-speed, solid-state computer called the Burroughs *B251* Visible Record Computer.

R. R. Eppert, president, stated that the Visible Record Computer is specifically designed for the banking industry to handle the largest data-processing problem in the world. He said that, while the system will have other applications, the company's marketing plans call for concentrating first on the bank market.

Named the Visible Record Computer because it selects and writes directly on individual account records, the computer reads information directly from checks, deposit slips, and other documents of varying thicknesses and sizes, processes the information, and automatically computes, selects, and posts directly to the correct customer's account record.

The system utilizes Magnetic Ink Character Recognition (MICR), announced last winter by the American Bankers Association as the "common language" for that industry.

The system will extend electronic data processing to a large number of banks of all sizes. Because of its low cost, many banks heretofore unable to justify the cost of a computer can have the benefits of high-speed computation, Mr. Eppert said. He also stated that large banks which may have been considering large-scale, general-purpose computers will find many advantages in this system.

A marriage of high-speed electronic computation, advanced magnetic techniques, and automatic handling of accounting forms, the system will automatically perform all of the work in a bank's bookkeeping and statistical analysis departments, including check handling, proving, bookkeeping, and preparation of customers' statements and bank records.

Flexibility of the system will permit banks to use it for checking and savings accounts, installment loans, mortgages, and other accounting operations. It will also provide accounting and statistical reports vital to bank management.

Four Units Employed

Four units comprise the system. The first is an electronic check sorter, said to be the world's fastest, a solid-state device announced by Burroughs last March. This machine sorts and reads checks, deposit slips, and other bank media through the means of the magnetic ink characters printed on these items, including the account number, amount, and other required information.

The second unit is the computer, a completely transistorized machine with magnetic core memory. The computer processes the information read by the sorter from the magnetic characters on the documents and sends it back to the third unit, the record processor. Here items are automatically posted on ledger and statement forms, proved, and the customer's current balance computed and printed.

The Visible Record Computer is controlled from a console, fourth unit of the system. It consists of program selector knobs, special controls, a panel of lights that displays status of the computer, and a keyboard which permits entry of unusual items if desired.

Instructions can be given the system to reject checks on which stop payment orders have been placed, and refuse payment of checks if an account is overdrawn. It also can accomplish balance transfers, compute and post service charges and account profitability information, and accumulate trial balances all at the same time.

As a by-product of processing operations, the computer system will provide accounting and statistical data needed for management decisions, including reports on inactive, overdrawn, and closed ac-

counts as well as significant balance changes.

Individual account information printed in standard type on the face of each ledger is also stored electronically in two narrow magnetic stripes on the back of the form. This enables the machine to read the ledger as well as carry out special instructions also stored in the stripes.

The pair of stripes, performing the same function as magnetic tapes used by other computers for input and storage of data, have a capacity of seven "words" of information. (A computer "word" consists of 12 digits plus sign.) They will contain such information as account number, balance, account activity, check and deposit counts, and numerous computer commands.

Computer programs are stored on long-lasting Mylar plastic tapes, which are easily installed on tape readers in the control unit. The system may use up to 12 tape readers, permitting more than 2,500 programming instructions at any one time. A library of standard programs covering a range of applications will be provided by Burroughs to banks using the new computer system.

Storage of programs and individual account information of Mylar tapes and magnetic ledger stripes leaves core memory of the computer free for intermediate storage of data, totals, and constants needed for arithmetic functions.

Advanced Memory Core Packets

The system will utilize advanced new memory core packets, each with a capacity for storing 10 computer "words." This will permit a bank to tailor capacity of the computer to its individual needs, saving the expense of buying core storage that will not be used. As a bank's requirements grow, the core memory capacity can be increased simply by inserting additional memory packets into the computer.

In addition to the Visible Record Computer's low initial cost compared to other automatic data-processing systems, installation costs are held to a minimum. Specially built rooms, air conditioning, and humidity controls required for most computers are unnecessary.

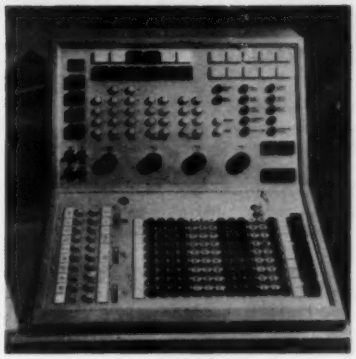
ENGINEER checks circuitry of Burroughs B251 electronic data-processing system. Solid-state, the computer has over 4,400 transistors and magnetic core memory. Memory is "packaged" in quickly installed push-pull packets, each capable of storing 10 computer "words." This permits bank to tailor computer capacity to its own needs since core memory can be increased simply by inserting additional memory packets.

Only One Attendant Needed

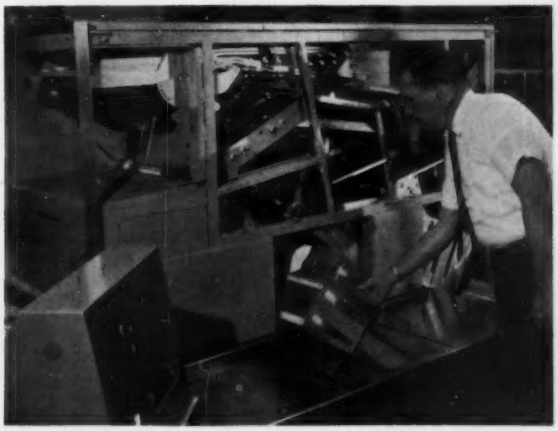
The system is simple to operate and requires only one person in attendance. It is capable of performing 4,000 arithmetical functions a minute.

A wide-line printer with 160 print positions is used to up-date ledgers and prepare other visual records. It prints at the rate of 200 lines per minute. Printing format is controlled from a plugboard in the console.

The new data-processing system is the culmination of 5 year's intensive development at Burroughs Corporation's Center at Paoli, Pa., where scientists and engineers also have designed advanced equipment such as the guidance computer for the Atlas Intercontinental Ballistic Missile.



CONTROL CONSOLE OF B251 electronic data-processing system consists of program selector knobs, special controls, panel lights that display and indicate status of any program being processed in computer, and a keyboard which permits entry of unusual items if desired.



FIRST OF FOUR UNITS which comprise Burroughs B251 electronic data-processing system is the electronic check sorter (above, left). It sorts and reads checks at the rate of 1,500 checks a minute—also sorts and reads deposit tickets and other bank media—all through means of magnetic ink characters printed on each item, including the account number, amount, and other required information. Above, right: With side panel off, interior of processor unit of the system shows the record carrying train and location of ingoing and outcoming accounts. This unit prints standard type on the face of each account—also stores information electronically in two narrow magnetic ink stripes on the back of the form. This enables the machine to read the account as well as carry out any special instructions.

THE DASHBOARDS of the 1960 Imperial (above) and Chrysler automobiles will be illuminated by Sylvania "Panelescent" lamps. The new light source, which produces light over the entire surface of a panel by the principle of electroluminescence, offers the important safety advantage over conventional incandescent-lighted dashboards of reducing eye strain in night driving. Panelescent lamps are virtually unbreakable and are cool to touch. They outlast conventional bulb types 10 to 1.

Panelescent Dashboard Lamps Offer Important Safety Advantage

DASHBOARDS of 1960 Chrysler and Imperial automobiles will be illuminated by Sylvania "Panelescent" electroluminescent lamps, it was announced jointly by Chrysler Corporation and Sylvania Electric Products, Inc. Sylvania is a subsidiary of General Telephone & Electronics Corporation.

R. M. Rodger, chief engineer of the Chrysler and Imperial Division, said the new light source offers the important safety advantage over conventional incandescent-lighted dashboards of reducing eye strain in night driving.

"Because electroluminescence is a low-level light source, there is less eye adjustment when the driver looks from the road to the instrument panels and back to the road," Mr. Rodger said. "Retinal images are eliminated and night driving is much more restful."

The Panelescent lamp produces light over the entire surface of a panel by the principle of electroluminescence—the creation of light through the excitation of phosphors placed in an electric field. Only 0.025 of an inch thick, the lamp produces a uniform light without the use of bulbs, tubes, filaments, or cathodes. Its construction consists of a porcelainized steel sheet with a ceramic-phosphor coating.

Many Applications Possible

Marketed under the trade name "Panelescent," the lamps have been utilized in radio and clock faces, telephone dials, switch plates, thermometers, house numbers, night lights, highway and conventional signs, aviation and automotive instrument clusters, and many other applications. More than 1 million Panelescent lamps have been produced by Sylvania at its manufacturing facility in Salem, Mass.

In 1960 Chrysler and Imperial dashboards, two types of Panelescent lamps will be used. The numerals and letters on the speedometer; odometer; fuel, amperage, oil, and temperature gauges; and radio dials will be backlighted by flat, wafer-thin Panelescent lamps that produce a blue-green light. Moving across the dial faces will be flowing pointers in contrasting colors, to give the driver the information he wants at a glance. Both the pointers and flat pieces are Panelescent lamps.

Lamps Virtually Unbreakable

The lamps are virtually unbreakable. They can be dropped on the floor and stepped on without damage. The life expectancy for maximum light output exceeds 10,000 hours, in contrast to the 300- to 1,000-hour life of a typical auto electric bulb. A Panelescent lamp never burns out suddenly, and at 40,000 hours, the lamp produces 25 to 50% of its original output.

"Panelescent lighting is very rapidly taking its place alongside the incandescent lamp and fluorescent lamp as a major light source," according to F. J. Healy, president of Sylvania Lighting Products, a Sylvania division. "Its potential applications and adaptations in virtually every field of endeavor are limitless. For low intensity applications, it is the most economical, the longest-lasting, the toughest in construction of any light known or contemplated."

Mr. Healy explained that evenly distributed illumination has always been a goal of the lighting industry. "In the Panelescent lamp we have a light source which provides even illumination without requiring fixtures, shades, or louvers to reduce glare. For the first time we have an 'area' source of lighting."

First of Its Scope in Auto Industry

"The dramatic application of Panelescent lighting to the instrument clusters of the 1960 Chrysler and Imperial cars, the first of is scope in the automotive industry, has been made possible at this time by Sylvania's extensive phosphor improvements and introduction of new manufacturing techniques," Mr. Healy said.

He pointed out that in addition to its use in instrument clusters, Panelescent lighting has many other potential automotive applications, for such equipment as automobile ceilings, tail lights, floor lights, and license plates.

A companion to the automotive application is Sylvania's development of a Panelescent-lamp super-highway marking sign having many more times driver readability than conventionally lighted signs at one-half the power consumption cost.

The first Panelescent highway sign has been successfully tested on the Roseville Freeway by the California Division of Highways. The sign is expected to have wide applications in marking highway turn-offs, routes, mileage, and traffic warnings.

"When electroluminescence is marketed as a high-intensity light source—and that development could come in a relatively short period—it will rival every other form of lighting now in existence," Mr. Healy predicted.

Paving Process Uses By-Product of Power Plant

A new, less expensive paving process is now being tried on Long Island (N.Y.) for the first time by the Long Island Lighting Company, using a waste product of the utility's electric power plants. The by-product, fly-ash, a residual of the company's electric generating operation, is one of the main ingredients in the new process which is being used to pave the parking area of the company's nearly completed 25-acre division headquarters in Brentwood.

The 19-acre parking area, constructed by Lizza Brothers, Oyster Bay, is being completely paved through the use of Pos-O-Pac, the new patented process which produces a surface with a density and hardness of poured cement. This cement-like result is accomplished by the addition of fly-ash and lime to the original surface material. A measured amount of moisture is added to this mixture and it is then rolled into a smooth and compact finish, ready for almost immediate use.

Translucent Ceramic Displays
High Degree of Strength, Heat Resistance

A CERAMIC MATERIAL described as "history-making" in its unique combination of properties has been announced by Dr. Guy Suits, vice-president and director of research for the General Electric Company (GE).

"For the first time in history," said Dr. Suits, "a polycrystalline ceramic that readily transmits light has been made from powders. In addition to transmitting light, the new material possesses the extremely high strength characteristic of alumina ceramics, can withstand much higher temperatures than most ceramics now in use, and can be pressed into any shape desired. No other material combines translucence with this degree of strength, heat resistance, and ease of fabrication."

"Lucalox," as GE calls the new material, is made from powdered aluminum oxide. It is closely related to sapphire and ruby gem stones, which are single-crystal aluminum oxide. But GE's polycrystalline form of the same compound is superior to these gems in its ability to withstand high temperatures without deforming, according to Dr. Suits. Lucalox has the composition of a ceramic, the structure of a metal, and the light-transmitting ability approaching that of glass, Dr. Suits added.

The unique characteristics of Lucalox result from the fact that the microscopically small pores, or "bubbles," that are normally found in ceramic materials have been entirely removed, a feat that had been previously considered impossible.

Because of the elimination of the pores, it is possible to read through a sheet of Lucalox when it is laid flat upon a piece of paper. At greater distances it appears translucent, resembling frosted glass. At least 90% of the light in the visible spectrum is transmitted through the new ceramic, Dr. Suits announced.

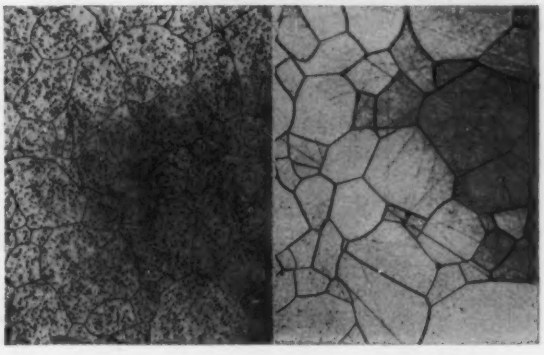
The basic material of Lucalox is fine-grain, high-purity aluminum oxide, or "alumina." The powder is pressed at room temperature, then fired at temperatures that are higher than usual for ceramics.

Lucalox was first made by Dr. R. L. Coble, of the GE Research Laboratory. Following his first research, important contributions were made by Dr. P. D. S. St. Pierre, Dr. Edward Stover, and Arno Gatti. The problems of making the process commercially feasible are being explored by Dr. C. A. Bruch.

"This is one of the most significant advances in the field of ceramics in hundreds of years," declared Dr. J. H. Hollomon, manager of the GE Research Laboratory's metallurgy and ceramics research department. "Lucalox resulted from an extensive investigation of the basic principles of the sintering process. Its creation represents an achievement of the first order, illustrating our ability to create entirely new materials when we gain better understanding of the fundamental scientific processes involved.

"The development of Lucalox," according to Dr. Hollomon, "should greatly enlarge the scientific, military, and industrial uses of ceramics. As has been the case with many new materials, Lucalox should also extend the range of instruments and devices that are presently limited by the physical characteristics of available materials. One example would be high-intensity incandescent and discharge lamps, which are now limited by the heat-resistance of their transparent envelopes, in some cases. Fused quartz,

NEW CERAMIC (left) developed by scientists at the GE Research Laboratory, resulted from the removal of all the microscopic pores, or bubbles, that make conventional ceramics (right) appear opaque. Named Lucalox, the highly dense material is made from aluminum oxide powder, pressed into shape and sintered. One can easily read through a polished specimen, like that shown here, when it is placed flat against printed matter; at greater distances, it resembles frosted glass.



PORES in conventional ceramic (dark spots in photomicrograph at left) scatter the light, making the material opaque. In the highly dense Lucalox (photomicrograph at right) pores are eliminated and the new material transmits at least 90% of the light in the visible spectrum. Scattering of light at grain boundaries (dark lines) prevents complete transparency.

Future Meetings of Other Societies

AIME, Fall Meeting, Metallurgical Society, Nov 2-5, Morrison Hotel, Chicago, Ill. AIME, 29 W 39 St, New York 18, N. Y.

11th Exposition of the Air-Conditioning and Refrigeration Industry, Nov 2-5, Atlantic City, N. J. Ted Kellog, 1346 Connecticut Ave, NW, Washington 6, D. C.

6th Institute on Electronics in Management, Nov 2-6, The American Univ, Washington, D. C. Lowell Hattery, 6th Institute, Am Univ, 1901 F St, NW, Washington 6, D. C.

ANS, Winter Meeting, Nov 4-6, Sheraton Park Hotel, Washington, D. C. G. L. Weil, 1025 Connecticut Ave, NW, Room 613, Washington 6, D. C.

P. E. A., Fall Meeting, Meter Committee, Nov 5-6, Pick-Roosevelt Hotel, Pittsburgh 22, Pa. W. E. Osborn, Duquesne Light Co, 2101 Beaver Ave, Pittsburgh 33, Pa.

8th Annual Instrumentation Conference, Nov 5-6, Schl of Engg, Louisiana Polytechnic Institute, Ruston, La. Stewart Baggarly, LPI, Ruston, La.

The Institute of Radio Engineers

Radio Fall Meeting, joint EIA, Nov 9-11, Syracuse Hotel, Syracuse, N. Y. V. M. Graham, EIA, 11 W 42 St, New York 26, N. Y.

4th Instrumentation Conference, Nov 9-11, Atlanta, Ga. B. J. Dasher, Schl of Elec Engg, Georgia Tech, Atlanta 13, Ga.

1959 New England Research and Engineering Meeting (NEREM), Nov 17-19, Boston Commonwealth Armory, Boston, Mass. Joseph Shaughnessy, Sanborn Co, Boston, Mass.

NEMA, Convention, Nov 9-13, Atlantic City, N. J. Russell Gingles, NEMA, 155 E 44 St, New York 17, N. Y.

National Fire Protection Association, Fall Conference, Nov 11-13, Hotel Fort Des Moines, Des Moines, Iowa.

2nd Annual Texas Conference on the Utilization of Atomic Energy, Nov 12-13, Texas A & M Coll, College Station, Texas. G. M. Krise, Radiation Biology Div, Texas Engg Experiment Station, Texas A & M College System, Coll Sta, Texas.

EIA, JEDEC General Conference, Nov 16-18, Bellevue-Stratford Hotel, Philadelphia, Pa. R. G. Roesch, 1068 Clinton St, Syracuse 4, N. Y.

Automation 1959, Exposition and Congress, Nov 16-20, New York Trade Show Bldg, New York, N. Y. Richard Rimbach Assoc, 845 Ridge Ave, Pittsburgh 12, Pa.

IAS, National Air Transportation Meeting, Nov 17-18, Fairmont Hotel, San Francisco, Calif. IAS, 2 E 64 St, New York 21, N. Y.

ISA, Symposium on Solid State, Philadelphia Section, Nov 23-24, Ben Franklin Hotel, Philadelphia, Pa. ISA, 313 Sixth Ave, Pittsburgh 22, Pa.

ASME, Annual Meeting, Nov 29–Dec 4, Chalfonte-Haddon Hall, Atlantic City, N. J. L. S. Dennegar, 29 W 39 St, New York 18, N. Y.

27th Exposition of Chemical Industries, Nov 30–Dec 4, New York Coliseum, New York, N. Y. E. K. Stevens, International Exposition Co, 480 Lexington Ave, New York 17, N. Y.

which is often used for high-temperaure lamps, performs satisfactorily up to 1,800 F; Lucalox is stable at temperatures close to 3,600 F."

Another likely application for Lucalox is in the banks of infrared lamps that are used to test the heat-resistance of missile nose-cones and other space-vehicle equipment. It may also be used as an electrical insulator and as a material for gem bearings in delicate equipment, according to Dr. Hollomon.

Present ceramic materials can be divided into three general categories:

Conventional ceramics, such as porcelains, in which the crystals are bonded together by low-melting glass—these approach, but do not reach, the 100% density of the new material. They are limited by the low melting point of the bonding glass.

Oxide ceramics, more-or-less single phase—these are stronger than the porcelains, but, filled with light-scattering pores, they are opaque.

Single crystals, such as sapphire and ruby—these are transparent, but are limited in size and shape and are extremely difficult to fabricate.

Lucalox has a metal-like structure, in that its crystals are bonded directly to one another, with neither pores nor a glass matrix between them. Information gained from the study of this material may consequently be applied to powder metallurgy.

Polaris Switchboard for George Washington

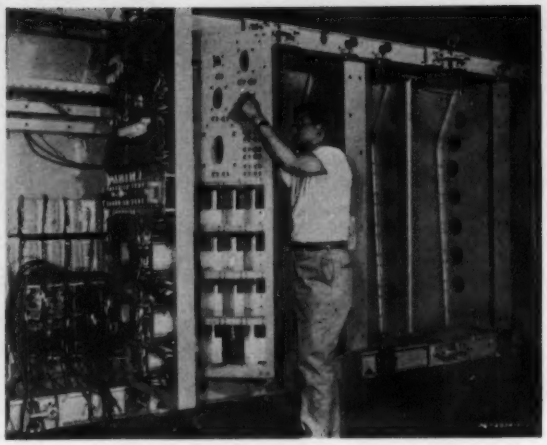
With the launching of the first Polaris missile-equipped submarine, the nuclear powered *George Washington,* the Navy Department revealed the complexity of some of the fire control apparatus needed in the newest submersible for the U.S. Navy's "Weapons for Peace" program.

Nerve center of the missile weapons system—and major clearing house for transmitting and switching both power and information to and from the fire control panel which launches the Polaris missile—is an especially constructed switchboard that had to be designed and built to be installed in the submarine through a 25-inch hatchway, Navy spokesmen said.

Built by Burroughs Corporation, the switchboard is unlike most shipboard installations because of the changes necessary to conform to atomic-power undersea craft. It curves to fit the hull and actually is installed in two sections—split to meet space limitations. Each section is monitored by a specially trained seaman. There are 12 cabinet units in all.

The switchboard on the *George Washington,* like much of the craft's technical equipment, is a forerunner of things to come on surface vessels. Through the board, the weapons systems transmit digital information, synchronization, and power data which checks missile environmental conditions, activates storage batteries, feeds navigational data to fire control equipment, and prepares information to operate launching equipment among many other tasks.

The 12 cabinet units fill an area about 20 feet long by 6 feet high. Each cabinet unit utilizes about 20 square inches of floor space. There are 135,000 connections and 265,000 feet of wiring for each switchboard.



CHECKING OVER and installing thousands of components is the job of Burroughs Corporation engineers working on the Polaris Switchboard, designed to be installed in submersible craft for the U. S. Navy. Notice the peculiar beveled construction, designed to fit tight against the submarine's hull. The switchboard is the nerve center of the Polaris missile weapons system.

Similar switchboards are scheduled for installation aboard the *598* series of submarines of which the *George Washington* is the first, the Navy said. A second group of specialized boards in all probability will be designed for the advanced *608* series of high-speed, super-range submarines, spokesmen indicated.

The complex board was built by Burroughs under a prime contract with the Navy. Burroughs also has a subcontract with the General Electric Company's Ordnance Department at Pittsfield, Mass., for the construction of printed circuits and electronic modules for the Polaris missile fire control mechanism and data-processing equipment.

New Shapes and Sizes Possible for Fused Silica

High purity fused silica now can be formed into cylinders, domes, crucibles, rods, and slabs through an adaptation of the Multiform process, developed by Corning Glass Works, Corning, N. Y. Sizes equal to any achieved by conventional ceramic forming processes are possible.

Corning Glass Works photo

The resulting ceramic-like material is known as Multiform fused silica. The development will make it possible to exploit the unique thermal and electrical properties of pure silica glass in many flight vehicle applications.

Corning fused silica, the parent material, is one of the purest glasses commercially available, according to the company. It is made by an unusual process in which silica in the gaseous state is condensed into a solid slab. Impurity levels in the glass are on the order of one part per million. Because of its unusual thermal and electrical characteristics, Multiform fused silica currently is undergoing evaluation for possible use as a flush-mounted radome in a military missile.

Most properties of Multiform fused silica vary only slightly from values obtained for the parent glass. The material can withstand long-term use at temperatures over 1,700 F and intermittent use to 2,250 F. The softening point is 2,880 F. Coefficient of thermal expansion is 3×10^{-7} per degree F, giving the material excellent resistance to thermal shock. Multiform fused silica is extremely viscous at high temperaures and tends to sublime before it can liquefy and flow. Tests of the material in a plasma jet show uniform removal of sample surfaces by ablation.

The material also displays extremely stable dielectric constant and a low loss tangent over a broad temperature range. At a frequency of 8.6×10^9 cps, the dielectric constant is 3.58 at 77 F and 3.57 at 750 F. At the same frequency, dielectric loss factor ranges from 0.00069 at 77 F to 0.00098 at 750 F.

The Multiform process permits forming of powdered glass into a wide variety of shapes, either by slip-casting or dry pressing. The resulting opaque, fine-grained structure can be machined to tolerances of ± 0.001 inch. It has a density of 1.9 to 2 grams per cubic centimeter, or 120 to 125 pounds per cubic foot, and a porosity of 9 to 13.6%.

◄ IN THE SEARING HEAT of a plasma jet, which can create pinpoint temperatures like those experienced in missile re-entry, Multiform fused silica vaporizes rather than melting and flowing as a liquid.

Missiles Launched from Railroad Cars

A highly mobile system for the launching of intermediate range and intercontinental ballistic missiles from specially built railroad cars has been developed by ACF Industries, Inc., and American Machine & Foundry Company (AMF).

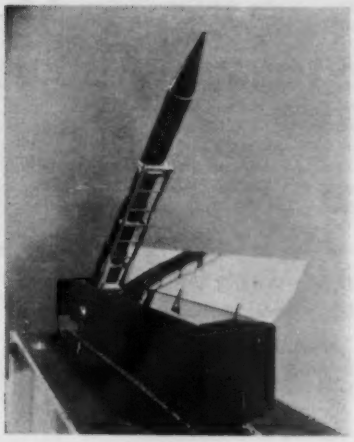
According to J. F. Clark, president of ACF Industries, and C. L. Burgess, AMF president, the railroad car launching system offers the following important advantages to current national defense capability:

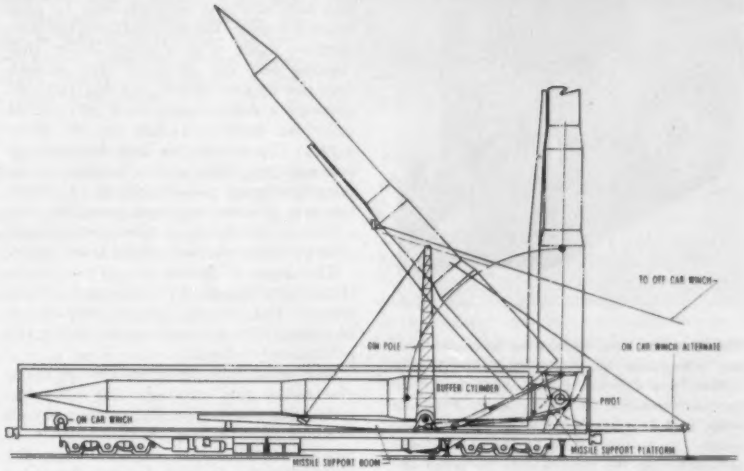
1. A broad extension of our ability to retaliate from any point in the vast 225,000-mile network of United States railroads now in existence. Railroad launching provides mobile dispersion that will complement present hard-based missile systems.
2. The system could be quickly implemented into the structure of present railroad lines by combining railroad and current missile launching techniques.
3. Speed of missile mobility could be used to confuse the enemy through rapid changes in the launching pattern.

Periodically, the railroad missile launchers would return to a support facility for major maintenance or missile exchange, although a minimum number of launchers would always be in the field. The railroad missile launcher would be capable of launching missiles from either sidings and spurs or be able to stop and launch from any point on a railroad line.

AMF has also been engaged in the study and development of ground support equipment for the Titan, Atlas, and "Dyna-Soar" programs. ACF Industries has also been active in a number of defense projects.

HIGHLY MOBILE system for the launching of intermediate range and intercontinental ballistic missiles is illustrated *(right)* in this model of a railroad car launcher. Developed by ACF Industries, Inc., and American Machine & Foundry Company, the system would be capable of launching retaliatory missiles from railroad sidings or spurs or be able to "stop-and-launch" from any point on a railroad line, officials said. *Below:* Gin pole concept of mobile missile launcher consists of a missile support boom and platform, pivoted at the trunnion located 10 feet above floor level, and the gin pole which is pivoted approximately 20 feet from the trunnion at floor level. The gin pole carries the cable as it elevates. The cable is attached to the boom approximately 40 feet from the trunnion. With the winch located in the launcher car, a second gin pole would be required, extending horizontally out of the rear end of the car at floor level.





Electronic Monitor Gives Blood Pressure Readings

A continuous blood pressure electronic monitor, invented by an English doctor and now in commercial production, gives a continuous reading of a patient's blood pressure and regulates the supply of drugs to the patient to maintain a predetermined blood pressure level.

Called the blood pressure follower, it is the invention of Dr. J. H. Green of the department of physiology, Middlesex Hospital Medical School, London, England. The manufacturers are Winston Electronics Ltd., Govett Ave., Shepperton, Middlesex, England. The instrument has been in use for the last 18 months in the operating theater of a London hospital.

Instead of the normal method of using an arm cuff together with a stethoscope to listen to sounds in the artery below the cuff or some mechanical or electrical means of recording arterial pulsation, the new instrument requires only that a small digital cuff combining a crystal microphone be fitted over the patient's finger.

The main disadvantage of the arm-cuff method is that it causes discomfort to the patient if left on for any length of time, and the stethoscope can be used only in quiet surroundings and provides only spot readings. Another method, in which a hollow tube is inserted into an artery, also causes discomfort and carries with it the danger of clot formation in the artery itself. The new method is so painless that it can be used while the patient is asleep, when the necessary information will be relayed automatically to a remote point, such as a nurses' room. Any abnormal change in pressure immediately alerts the alarm system of the equipment, and bells or lights will give warning at the control point.

By using a finger as the source of pulsation, a piezoelectric crystal, which acts as a microphone, is placed over the digital artery. The finger is then inserted in an occlusion cuff; the cuff is enclosed in a rigid plastic tube and inflated from a small pump in the apparatus. The piezoelectric crystal responds to variations in the digital pulse and the impulses from the crystal are used to control the pressure in the cuff, thus providing a continuous recording.

An electromagnetic valve opens and closes with the pulsations. A fixed leak deflates the cuff when arterial pulsations stop as the pressure in the cuff exceeds systolic arterial pressure; the electromagnetic valve then opens automatically, more air is pumped into the cuff, and so the cycle is completed and then repeated for any required period. The cuff pressure in this way follows changes in systolic blood pressure and all such changes are revealed on the instruments of the apparatus.

Because the entire finger is inserted into the rigid plastic tube which contains the pneumatic cuff, the risk of edema is minimized when used over a long period. Moreover, the cuff can be worn for many hours without discomfort and records can be obtained over still longer periods merely by changing the finger used every 4 hours or so.

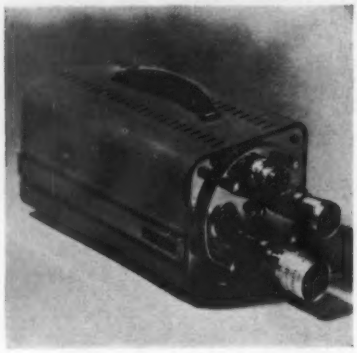
The device enables a continuous trouble-free record of blood pressure changes to be made throughout an operation or in the ward. Also, it is now possible to preset the required blood pressure level for as long as required; a solenoid device automatically controls the intake of drugs, so that blood pressure constantly remains at the required level. Any variation from the predetermined maximum and minimum automatically sets off an alarm immedi-

ately, at the same time cutting off the supply of the drug.

In cases of shock from accident or surgical operation, where blood pressure and the impact of the shock are closely interrelated, the instrument provides constant observation and gives prior warning of dangerous changes in blood pressure level. This information is of inestimable value, especially where blood transfusions have been given.

Direct-Wire TV System for Schools and Universities

A direct-wire television system aimed at breaking the "present price barrier" has been developed by Argus Cameras, a division of Sylvania Electric Products, Inc., it was announced by C. H. Harris, president of Argus. Sylvania is a subsidiary of General Telephone & Electronics Corporation.



HEART of the new direct-wire television system introduced by Argus Cameras is this vidicon-type camera. Exclusive of lens, the camera measures 12 inches long, 7 inches wide, and 6 inches high. It weighs approximately 16 pounds. Because its controls are self-contained, the camera may be wired directly to any standard television receiver to which it will transmit an image on any channel from two to six.

The heart of the system is a lightweight vidicon camera that will have a manufacturer's suggested list price of $595.

Mr. Harris said that unlimited new fields will be opened by this low-cost system, while at the same time, many universities and schools will be able to add direct-wire television to their classroom aids immediately.

Other factors expected to stimulate use of the Argus equipment are its lightweight portability, its simplicity of operation and maintenance, and the fact that the camera can be used to provide an image on any standard television receiver.

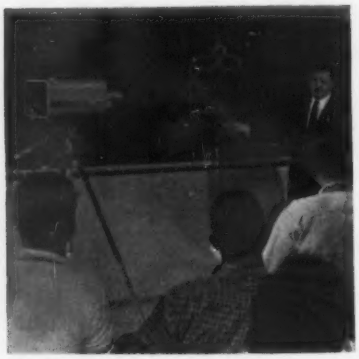
The camera signal may be received on any unused channel from two to six, allowing up to five cameras to be used on separate channels. Through the use of a junction box, multiple receivers may be used simultaneously. Simple coaxial cable connections made with a screw driver link cameras and the receivers. The camera does not require special lighting and will transmit a sharp image using any one of the three lenses available for its turret mount. The mount has been designed to accommodate wide-angle, standard, and telephoto lenses simultaneously. A fourth lens seat position has been provided with a built-in extension to allow for extreme close-up focus with any of the three lenses.

The cameras houses its own controls eliminating the need for a second control console. The simplified Argus controls can be operated by a layman after reading the printed instructions.

The camera construction has been engineered so that any radio and television technician can service the camera. As an example of this ease of maintenance, it was pointed out that in addition to the vidicon the camera contains only five tubes which are stock items in radio and television stores. To assure convenient portability, the camera weighs approximately 16 pounds and offers a top-mounted carrying handle making it a simple unit that can easily be carried from place to place. The camera may be mounted on any standard camera tripod.

In addition to schools and colleges, it is expected the camera will find wide use in hospitals where it can be used for teaching and for patient observation. Fire departments and police departments should be able to use it in training sessions and in field work such as fire and traffic control. Supermarkets, department stores, and all other type retailers should find it an invaluable training aid, and also a deterrent to shop lifting and pilferage.

Besides making available the direct-wire television camera with its lenses, Argus Cameras is also putting on the market a 17-inch portable monitor receiver and a 23-inch monitor receiver. Accessories for the direct-wire system include varying lengths of coaxial cable extensions, a junction box for multiple direct-wire camera hook-up, other devices for multiple monitor and receiver hook-ups, and a line booster for use when cable length exceeds 1,000 feet.



AN UNATTENDED vidicon-type camera mounted on a conventional tripod is shown in use as an instructor puts himself "under the camera" with the Argus direct-wire television system. The camera, which carries a manufacturer's suggested list price of $595, is designed to bring closed-circuit television within the financial reach of school systems and universities where price has been a limiting factor.

A 23-INCH television receiver, such as the one shown in use, and a 17-inch television monitor, are being made available for use in the direct-wire television system. These receivers may also be used to view conventional television programs. Through the use of junction boxes, an unlimited number of receivers may be connected to as many as five vidicon-type television cameras in the Argus system.

Tapes Train Sonar Operators To Distinguish Fish from Enemy

High fidelity tape recordings—acoustic histories of the U.S. Navy's submarine hunter-killer squadrons on the high seas—are being used in a new training device to help SONAR operators distinguish the characteristic "bark" of a school of frolicking porpoises from the tell-tale blip of an enemy submarine.

International Telephone and Telegraph Corporation (ITT) Laboratories at Nutley, N.J., is completing a contract for the U.S. Navy, utilizing high fidelity recordings of actual SONAR searches to overcome this vexing problem of identification.

In addition to schools of fish, which can cast an electronic "shadow" on SONAR-scopes, underwater mountain peaks, old wrecks, and even masses of floating plankton or kelp tend to produce a confusing picture for the SONAR operator, it was pointed out.

Using principles similar to radar, SONAR sends out an electronic pulse and, by identifying the return echo and measuring the elapsed time from transmission to reception, permits operators to detect the presence of undersea or surface vessels in the area.

Intended for installation at Navy training schools in Key West, Fla.; San Diego, Calif., and elsewhere, the SONAR Operators' Target Classification Trainer System is linked side-by-side with actual SONAR equipment, allowing trainees to monitor many of the situations they may encounter while on active duty.

Magnetic tape used in the device being readied for production by the ITT research and development center runs at a speed of 60 inches a second, with 14 separate recording tracks of information being "played" simultaneously. In addition to identification of the target, its bearing can also be simulated by the system.

Designed to military specifications to

withstand excessive vibration, exposure, humidity, and other conditions to make it suitable for shipboard installation, the SONAR trainer is slated for quantity production at the ITT–Federal Division in Clifton, N.J.

Intercommunication System Humanizes Telephonic Contact

A fully transistorized intercommunication system, which substantially reduces cost of installations and humanizes telephonic contact, has been developed by Dictograph Products Inc., Jamaica, N. Y

Designed to solve the simplest to the most complex intercommunications problem, the new single system replaces three systems currently produced by the company, and provides important new features, according to W. N. Brown, marketing vice-president.

The system ranges in cost from $250 for a typically small installation to more than $100,000 for a large complex installation.

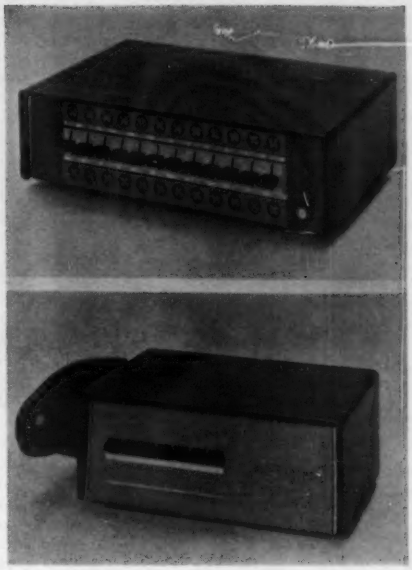
One feature is a newly developed "magic-eye" which indicates who is calling and automatically leaves a message. In addition, a hidden lamp which emits a red, attention arresting glow announces incoming calls to the executive.

The system comprises executive, master, and personnel stations. It is completely independent requiring no switchboard operator and provides 100% trunkage which eliminates artificial busy signals. It can be linked to a central dictating facility, paging system, and music distribution center. Provisions for installing these special services are built into the system. Also, it can be adapted to perform unusual services such as drawing the drapes, opening a door, and rolling out a bar. Individual stations can operate at distances up to 3,000 feet and up to 5,000 feet under optimum conditions. However, the system can cover much longer distances (a recent Dictograph installation covers 16 miles).

Power requirements in the new system have been vastly reduced. It can be run on a much smaller battery eliminator than heretofore possible or on inexpensive batteries which will last for their shelf lives.

Patents covering design and circuit features of the new system are pending.

The executive station also features hands-free operation, right-of-way priority, an advanced acoustical design with two-channel transistorized amplifier and a conference circuit. Its walnut cabinet can house three different size stations permitting contact with 12 to 24 people. Larger stations with as many points as required are available. Compact, 17 by 4½ by 8½ inches, and of modern design, it is suitable for desk top use or can be installed in a nearby cabinet or bookcase. A handset can be added or mounted separately for private conversation when others are in the room. When the handset is used the amplifier is not activated, thereby eliminating excessive battery drain. The conference circuit has been standardized so that several keys may be thrown simultaneously and incoming parties automatically signal themselves on the "magic-eye" as they join the conference.



THE EXECUTIVE (*right, top*) and master (*right, bottom*) stations are part of a fully transistorized intercommunication system introduced by Dictograph Products, Inc. The executive station has a "magic-eye" which indicates who is calling and automatically leaves a message if the executive is away from his desk. It features hands-free operation, right-of-way priority, and advanced acoustical design with 2-channel transistorized amplifier and a conference circuit. A handset can be added or mounted separately. The standard walnut cabinet can house three different size stations permitting contact with 12 to 24 people. Large stations with as many contact points as required are available. The master station comes in standard walnut or metal cabinet and can be converted to any one of five size stations allowing contact with 6 to 23 points and more as needed. It also has a "magic-eye" indicator and can be used to initiate conferences. The system ensures complete privacy. Dictograph's security circuits permit no one to break in on a call.

The new master station employs the most advanced circuitry and makes use of induction coils for increased range, clarity, and conference facilities. The standard cabinet can be converted to any one of five stations allowing contact with 6 to 23 points and more as needed. The polyurethane base makes it "skid-proof" so that it holds its position on the desk when keys are depressed. A metal cabinet is available for master stations, if desired.

Dictograph developed an improved mechanical assembly for its system. It makes all parts easily accessible for service or repair. Also, a new highly flexible instrument cable was developed and produced to eliminate the possibility of broken circuits.

Personnel stations for limited call points such as store room, mail room, and file section are available as wall or desk units. Personnel stations can call one, two, or three points depending upon the model. Almost all of them can be called by any number of stations desired.

The privacy which has been engineered into the system protects confidential conversations. It allows no one to break in on a call. Dictograph's security circuits are so advanced that its equipment currently is being used by the Federal Bureau of Investigation, Atomic Energy Commission, Central Intelligence Agency, and the Pentagon.

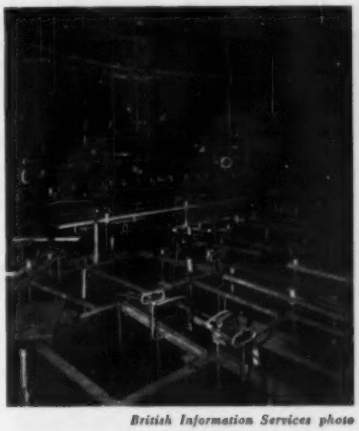
Polite and tactful right-of-way for executives is provided by the "magic-eye." It acts as a visual signal to tell the person being called that the executive would like to speak to him.

Another feaure of the system is its faithful reproduction of the voice. This is accomplished with the transistorized 2-channel amplifier and by preadjusting the station to the acoustical conditions of the room. Calls are signaled by a 1-stroke chime.

A typical installation is designed to follow the organization plan of a specific business, linking those people who must communicate regularly with one another.

Reactor Vessel Pressure-Tested on Site

The first of the two reactor pressure vessels for the Berkeley Nuclear Power Station in Gloucester, England, being built for the Central Electricity Generating Board, was recently pressure-tested and stress-relieved on site. Usually, stress-relieving is done in a large furnace in the manufacturer's works. This reactor vessel, however, was too big either for transporting or for testing in any existing furnace. It is a dome 80 feet high, 50 feet in diameter, of 3-inch- and 4-inch-thick mild steel, weighing 1,120 tons. Accordingly, it was transported section by section to the site of the Berkeley Nuclear Power Station in Gloucester by John Thompson Ltd.,



British Information Services photo

INSIDE the first of two reactor vessels for Berkeley Nuclear Power Station is the 165-ton diagrid fitted with heaters for stress-relieving the main vessel and the diagrid. In the background, barrel heaters and their associated bus bars are also seen on the 45-foot-high walls of the vessel.

British Information Services photo

BENEATH the bottom dome of the Berkeley reactor vessel, an engineer is seen checking thermocouple assemblies, of which more than 300 were used to ensure accurate temperature measurement during the stress-relieving operation. A 2-mw power supply was required in heating the vessel to 650 C.

Wolverhampton, England, manufacturers and testers of the vessel. There, it was welded together.

Five separate "rings" make up the body. Each 18½-foot domed end is composed of 63 "petals." The welding was all done by hand, electrically, after which the 2,500 feet of weld had to be X-rayed to the highest standards set by Lloyds.

The vessel was then heated to the requisite 650 C (1,202 F) and allowed to cool. The heating was accomplished by an ingenious system of induction coils suspended inside the reactor and heated by 2 mw of electricity. Two days were required to heat the vessel, and 14 days for it to cool. The idea for this process—believed to be generally applicable—was developed by the operating and testing department of the company in collaboration with their Welding Research Laboratory.

For the process of pneumatic testing, all inlets and outlets were blanked off and all apertures in the 11-foot thick concrete biological shielding closed. Compressed air was pumped in by four 2-stage compressors operating at 200 psig. The testing was completed in a 24-hour period.

According to the company, the use of a wide variety of instruments for this operation made possible measurements of change of shape of the vessel at various temperatures. More than 300 thermocouples for temperature measurement were positioned inside the reactor. The whole stress-relieving operation was regulated from a central control room.

Screen Printing Process Employs Copper-Bearing Paste

A method for producing printed wiring directly on ceramic bases, without the use of adhesives, employs standard silk screening techniques for forming the pattern. The basis of the new process, however, which was developed at Bell Telephone Laboratories, New York, N. Y., by A. W. Treptow and Lucille Finneran, is a specially formulated copper-bearing paste. Following the printing of the desired pattern on the ceramic base, the piece is fired in a 2-step process, resulting in a clean, durable pattern with excellent electrical characteristics.

In present methods of production, a sheet of copper foil is usually bonded to the ceramic or plastic base with an adhesive. The desired pattern is then produced by one of several methods, usually involving the removal of undesired material. The bond of the copper to the base thus is dependent on the strength of the adhesive. Often, it fails during subsequent processing operations, such as soldering or assembly.

Good bonds can also be developed when fired silver or fired molybdenum is used on ceramic bases. Silver is more costly than copper, it dissolves more quickly in molten solder than does copper, and under some conditions it is subject to migration and whisker growth. Molybdenum compositions are high in electrical resistivity and generally require electroplating to render them solderable and to improve the conductivity.

With the new process, a paste is prepared from a finely ground mixture of copper oxide and a special glass frit, blended with a standard silk screen printing vehicle. The paste is used to print the pattern on the ceramic, and the "card" is heat-dried to remove solvents. After drying, the card with its pattern is fired in air at 750 C for 20 minutes to burn off the printing vehicle. This operation leaves a nonconducting copper oxide pattern, ready to be reduced to metallic copper.

SCREEN-PRINTED PATTERN was produced by using a newly developed copper paste for circuits printed directly on ceramic bases. The new method, developed at Bell Telephone Laboratories, does not require adhesive to bond the copper pattern to the ceramic.

The second firing operation is conducted at 850 C for 30 minutes, in a controlled atmosphere containing hydrogen, nitrogen, and oxygen. The hydrogen in the atmosphere reduces the copper oxides to metallic copper, while the oxygen prevents reduction of other oxides in the system and promotes good wetting of the glass frit and the ceramic. Without the oxygen present, a poor bond results.

Printed wiring cards prepared this way can be dip-soldered without bond failure, and without the use of corrosive fluxes. In tests of bond strengths, 20-gauge headed wires were attached to the pattern with an area contact about 0.01 square inch. Bond failure did not occur until about 2,000-psi tensile pull, and even then generally involved breaking out the ceramic rather than bond failure.

With the oxygen in the controlled atmosphere, only about 5% glass frit is required in the paste to achieve good bonds. This small amount of inert material does not greatly affect the conductivity of the copper film. Resistivity of the film is in the order of 0.0015 ohms per square, which is well within requirements for typical printed wiring applications.

The composition of the controlled atmosphere may be forming gas (85% nitrogen and 15% hydrogen) with the addition of 0.4 to 4.5% oxygen. Such a gas mixture is noninflammable.

The process, suitable for automatic production techniques, has other potential applications. With suitable modification of the vehicle, the copper can be applied with a brush or spray gun. When fired, these coatings form a good base for making metal to ceramic bonds, using lead-tin solders.

Advanced Digital Plotter for Satellite and Missile Programs

An advanced high-speed digital plotter which produces satellite and missile performance data in a finished graph or plot form at the rate of more than 4,000 points a second has been developed by Lockheed Missiles and Space Division, Sunnyvale, Calif.

Designed and built by Lockheed's computer research department, it permits complete flight evaluations of Lockheed's high-priority space programs to be made 17 times faster and at least 12 times cheaper than possible with the old system of converting electronic signals into a finished graph form for engineering analyses.

The versatile plotter takes the processed data spewed out with lightning-like rapidity by Lockheed's advanced IBM *709* computers and turns it into a finished plot complete with printed annotations in one completely automatic operation.

One typical data reduction job which used to take 106 eight-hour working days now can be done in six days. In addition to the man-hours saved, the cost savings in paper alone is estimated at 7 to 1.

Two of the plotters, said to be the most advanced in operation today, are being used to accelerate the development of the Agena satellite in the Discoverer program and the U.S. Navy's Polaris ballistic missile programs.

Secret of the new plotter is its unique and complex transistorized circuitry, a system of feeding data into the machine by high-speed magnetic tape, and a bank of

PEN points to the bank of 1,024 styluses which is one of the keys to the super speed of the advanced digital plotter developed by Lockheed to transcribe the millions of bits of missile and satellite performance data into finished graphs for engineering analyses.

1,024 styluses which transcribes the curves and all necessary annotations in a single automatic operation to produce the finished plot.

This contrasts with the old plotter which uses a single stylus to peck out its curve—really a series of dots—at the pace of one a second and which is incapable of printing the annotations (i.e., time of engine firing, stage separation, accelerations, temperatures) which make the plot meaningful to the engineers. In the old system, the annotations had to be done by hand, a time-consuming operation.

A further drawback of the old system was that the magnetic tapes containing the computer-processed data could not be directly fed into the plotter. An extra delaying step of converting the data from tape to indexed cards was required. Besides valuable time lost in this extra handling, the card index method of introducing data to the plotter is many times slower than with tape.

L. J. Lauler, head of the computer research department, pointed out that it took from 3 to 4 hours using the old system to plot one channel of data telemetered from the missile or satellite, while the same operation now can be performed completely automatically in 40 seconds.

"Or, putting it another way," said R. L. Sapirstein, the young engineer who spearheaded the development of the super plotter, "where we used to produce 50,000 data points a day, we now have the capability of doing 282,000 a minute."

Another advantage of the plotter is that it produces a finished plot which is smaller, more compact, and easier to handle and store.

Comparing the volume of paper produced from one typical 24-hour orbiting period of the Discoverer for instance, with the old system, the plots would fill 15 volumes standing 39 inches high. With the new system, this same amount of data is contained in a single volume 1¼ inches thick.

The first plotter was delivered in December 1958 and it was purchased by the Navy for its Polaris development work. The second unit recently was completed for the Air Force's satellite projects managed by Lockheed.

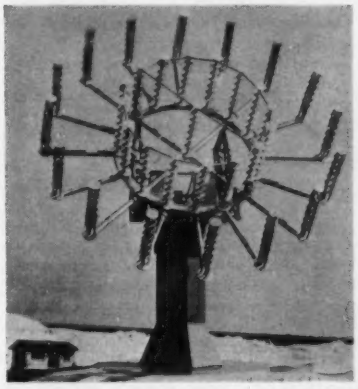
Wear Your ◆ AIEE Badge

Lightweight Array Antenna

A space vehicle tracking antenna which represents a departure from the "dish" type antennas currently in use has been purchased by the National Aeronautics and Space Administration (NASA) for installation at the Wallops Island test site in Virginia by Spring of 1960.

The lightweight 40-foot array antenna, currently under construction by The General Bronze Corp., Garden City, N. Y., will replace the 60-foot dish paraboloid and can be installed and erected with minimum cost and without complicated installation equipment. The new development, coupled with a Swept Volume Efficiency (SVE) unit can now provide a uhf antenna to track vehicles in space with an assembly which has only a fraction of the area and weight of the conventional dish-type paraboloidal antenna. Technical advantages include easier acquisition for space targets, more accurate tracking, and efficiency of performance.

The new antenna moves in azimuth and elevation. It is equipped with 33 end-fire elements. According to the company, it can be built at half the cost and with half the manpower previously required.



DEPARTING from the dish-type antennas currently in use, this 40-foot lightweight array assembly represents a new development for guided missile and space vehicle tracking. It is now under construction by The General Bronze Corporation.

Magnet Aids Atomic Energy Program

A large permanent magnet has been scheduled to work in America's Atomic Energy Program. It will help pump liquid sodium in a breeder reactor to be operated by the Argonne National Laboratory for the Atomic Energy Commission (AEC). To be known as the Experimental Breeder Reactor II (EBR-II), this reactor will produce electric power on the Argonne Idaho Division site at the National Reactor Testing Station near Idaho Falls, Idaho.

The magnet, made by The Arnold Engineering Company of Marengo, Ill., a subsidiary of Allegheny Ludlum Steel Corporation, weighs 1,720 pounds, and is made of Alnico V material. The over-all dimensions of the magnet are 52½ by 36 by 10 inches. It has a gap length of 16½ inches and a gap volume of 1,584 cubic inches. The density at the center of the gap is 1,100 gausses. About 500,000 ampere turns were needed to magnetize the unit.

It is customary to use an electromagnet in pumping the liquid sodium in this atomic energy application, but in this instance a large permanent magnet must be used because the magnet will be completely surrounded by the liquid metal.

The magnet was checked in a 3,000 hour test at temperatures up to 750 F prior to its being put into service at the Argonne National Laboratory.

The sodium used in the reactor acts as a heat transfer medium or "coolant" in much the same way as water can be utilized, but sodium does the job better. The liquid sodium absorbs heat from within the reactor, then it is pumped outside to heat water in a heat exchanger or boiler.

The huge permanent magnet will help

A WORKMAN at The Arnold Engineering Company plant is shown with a huge permanent magnet, said to be the world's largest, weighing 1,720 pounds, which will be used to pump liquid sodium for the breeder reactor at the Argonne National Laboratory for the AEC.

in the pumping of the highly radioactive sodium at elevated temperatures.

The pumps operate without moving parts. This is achieved by the interaction between a current passing through the sodium at right angles to a strong magnetic field. This interaction produces a force in the sodium when directed through a closed piping system serving as a continuous supply of liquid sodium.

One of the nation's leading atomic research and development centers, Argonne is operated by the University of Chicago for the AEC.

Data-Processing System To "Deliver" Telephone Books

Another large-scale task has been found for electronic data processing: the RCA *501* all-transistor system is slated to help distribute the Manhattan classified telephone directories in November 1960. The system is expected to increase the efficiency and accuracy of directory delivery, according to L. J. Jordan, general directory manager of the New York Telephone Company, and E. D. Foster, vice-president and general manager of the Electronic Data Processing Division of the Radio Corporation of America (RCA),, New York, N. Y.

After assisting in distribution of the Manhattan classified book, the system will be applied to delivery of the 32 other directories serving 3.5 million telephone users through New York City and Nassau, Suffolk, Westchester, and Rockland Counties. It is expected that 9 million directories will be delivered each year with the help of the high-speed electronic data-processing system.

The fully transistorized business-oriented electronic data-processing system will enable the telephone company's directory department to update customer delivery files on a daily basis and make delivery order changes even after the books have started rolling from the presses.

The computer procedure will apportion directories to the proper delivery truck and turn out printed orders for the R. H. Donnelley Corporation, distributor of telephone directories in the metropolitan area, taking into account the varying weights of the different directories and limiting individual bundles accordingly. Order slips will tell the delivery man what directories to take to specific offices, business establishments, homes, or apartments.

The *501* computer system will maintain 3.5 million customer delivery records on magnetic tapes comprising approximately 200 million total characters. The system will include an electronic brain, six magnetic tape memory units (each capable of feeding the electronic brain 33,333 characters a second for data processing), and a printer that will print directory delivery orders at the rate of 1,200 characters every second.

Manhattan telephone users receive 1 million directories twice a year: the alphabetical book in June and the classified in November. Each of the four remaining boroughs and the four counties served by the telephone company are covered once annually. The complexity of the operation is indicated by the fact that more Staten Island directories are distributed in Manhatten than Staten Island books on Staten Island.

Each borough or county is scheduled for directory distribution during a specific month of the year. In addition, the telephone company must provide books to new subscribers; to those whose directories have been destroyed, damaged, or lost; and at intervals to the area's thousands of public booths, depending on the location of the booth. Telephone books at some locations in Grand Central Terminal, for example, must be replaced or at least examined for wear and tear every four days.

Instrumentation for Study of Van Allen Radiation Belt

The U. S. Air Force Special Weapons Center (SWC), which made measurements of radiation discharged by the high-altitude Argus nuclear explosions, is rocketing more advanced counters to altitudes ranging up to 2,000 miles in an attempt to obtain a clearer picture of the mysterious Van Allen radiation belt. Details of the program were recently released by Lockheed Missiles and Space Division, Sunnyvale, Calif., which is providing the radiation-measuring instruments for the scientific project, known by the code name "Javelin."

The instrument packages are being hurled to altitudes of from 1,000 to 2,000 miles by 4-stage Aerolab rockets in a series of four probes conducted from the National Aeronautics and Space Administration's Wallops Island test site, Virginia.

It was the same team of the Air Force SWC, Lockheed, and Aerolab which conducted the Operation Jason phase of the historic Argus project last year. This consisted of firing high-altitude sounding rockets which carried instrumentation to measure the trapped electrons released by the detonation of nuclear warheads on Lockheed's *X-17* research rockets.

The instrument pods are designed to measure details of the Van Allen radiation belt heretofore unobtainable. Dr. Martin Walt, Lockheed nuclear physicist in overall charge of the project, said they are designed to measure not only the energy spectrum of the radiation, but the kind of particles as well.

Instrumentation includes scintillator radiation counters specially designed for high-altitude measurement of electron and proton activity. Also included are a Schoenstedt magnetic aspect senser and a hydromagnetic wave detector, designed to report on the instrument pod's position (attitude) in space at the time of the scintillator readings.

A specially designed electronic system converts the readings of all these instruments into signals capable of being telemetered to ground receiving stations, for recording and later analysis. This is necessary because the instrument packages will be fired on one-way trips, burning up on re-entering the earth's atmosphere after their job is done.

The instrumentation is compressed into a 15-pound conical package measuring 15 inches high, 13 inches in diameter at the base, and 4 inches in diameter at the tip. This package fits directly inside the nose cone of the scientific rocket. When the desired altitude is reached, it is capable of popping off the nose cone so that the measuring equipment is exposed directly to the outer space conditions it is designed to probe.

MODEL of all-transistorized RCA 501 electronic data-processing system is examined by L. J. Jordan, general directory manager of New York Telephone Co. System will aid delivery of telephone books.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

AUTOMATION, CYBERNETICS, AND SOCIETY. By F. H. George. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y., 1959. 283 pages, 5¾ by 8¾ inches, bound. $12. The book attempts to clarify the over-all picture of automation and its ramifications. The author begins with the distinction between nonautomatic and automatic

control of new and complicated pieces of machinery, and continues with an examination of the nature of science, and of automation. He then discusses the science of cybernetics, and its many diverse roots in mathematics; the design of high-speed computers; logic; and engineering. He concludes with a discussion of the implications that cybernetics has for the individual and for society.

DIGITAL COMPUTING SYSTEMS. By S. B. Williams. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 229 pages, 6¼ by 9¼ inches, bound. $7.75. The structure of modern electronic computing systems is described in relatively nonmathematical terms. Beginning with the various codes needed to represent data, the author describes the elements contained in modern computers including input and output devices, storage devices, circuits and components, and arithmetic units. A brief review of how digital computers are used to solve scientific, business, and data-handling problems concludes the book.

ELECTRICAL MACHINES. By C. S. Siskind. Second edition. McGraw-Hill Book Company, Inc., 330 W 42nd St., New York 36, N. Y., 1959. 563 pages, 6¼ by 9¼ inches, bound. $8. All types of modern equipment such as generators, transformers, rectifiers, and manually and automatically operated electric control systems are discussed. Because of the great importance of control methods in the operation of modern d-c and a-c motors, they are given special treatment in this edition. Such related topics as acceleration, reversing, dynamic braking and plugging, regeneration, and speed control are discussed in considerable detail. Also added is a completely new section devoted to the subject of rectifiers which includes the various metallic and arc-discharge types of equipment.

ENGLISH – SPANISH COMPREHENSIVE TECHNICAL DICTIONARY. Section II. By L. L. Sell. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 1,079 pages, 7½ by 11 inches, bound. $35. Originally designed as a supplement to the first volume, published in 1944, this work grew into a full section because of the recent advances in science and technology. This new section covers atomic and nuclear engineering, electronics, telecommunications, rocketry, space travel, television, jet propulsion, and radar. In addition, it provides a 1944-59 supplement to the fields covered in the first volume.

FLUCTUATION PHENOMENA IN SEMICONDUCTORS. By A. Van Der Ziel. Academic Press, Inc., 111 Fifth Ave., New York 3, N. Y., 1959. 168 pages, 6 by 8¾ inches, bound. $6.50. A study of the spontaneous fluctuations in the current passing through, or the voltage developed across, semiconductor samples or devices is presented. Constituting a survey of the present status of the theoretical and experimental work in this field, this book covers the characterization of noisiness in 2- and 4-terminal networks, generation–recombination noise in the case of thermal equilibrium, flicker noise in semiconductor material, noise in photoconductors and semiconductor resistors, shot noise in semiconductor diodes and junction resistors, flicker noise in diodes and transistors, and minimum noise consideration.

FUNDAMENTALS OF ELECTRON DEVICES AND CIRCUITS. By H. R. Weed and W. L. Davis. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1959. 591 pages, 6 by 9¼ inches, bound. $9.50. This survey of electron devices analyzes newer devices such as transistors, diodes, and magnetic amplifiers as well as conventional vacuum and gas tubes. A thorough analytical approach stressing physical phenomena is used where possible. Topics discussed include electron emission and acceleration; single-phase and polyphase rectifiers; diodes, triodes, and multigrid tubes; class-A amplifiers; push-pull and feedback amplifiers; transistor circuits; magnetic amplifiers; gaseous tube circuits; controlled rectifiers and inverters; regulators; operational amplifiers; and oscillators.

HIGH-RESOLUTION NUCLEAR MAGNETIC RESONANCE. By J. A. Pople and others. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 501 pages, 6½ by 9½ inches, bound. $13.50. The first part of this volume deals with the basic principles of the subject and the nature of the apparatus used. Emphasis is placed on those aspects, such as spectral analysis and the interpretation of chemical shifts, which are likely to be important in connection with chemical applications. The varied applications which are discussed in the second part include molecular structure determinations, isomerism, conformational analysis, tautomerism, hydrogen bonding and other intermolecular effects, chemical equilibriums, reaction rates, and chemical analysis.

INDUSTRIAL ACCIDENT PREVENTION. By H. W. Heinrich. Fourth edition. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 480 pages, 6¼ by 9¼ inches bound. $9. The various areas of industrial safety are discussed, ranging from the basis and philosophy of accident prevention to specific details on planning and executing a safety program to fit any size and type of operation. Practical data are included on finding and analyzing facts, selecting and applying corrective measures, the 4-step formula for supervision, and a short form safety course. In this edition, new chapters are given on safety psychology; nucleonics; small plant safety programs; and a "skeletal diagram" which presents, step-by-step, a complete accident prevention method for both safety and production.

INTERNATIONAL COMMITTEE OF ELECTROCHEMICAL THERMODYNAMICS AND KINETICS, NINTH MEETING, PROCEEDINGS. Published by Butterworth & Company, Ltd., Toronto, Ont., Canada, 1959. 489 pages, 6¼ by 10 inches, bound. $24. This collection of papers discusses thermodynamical data and potential-pH diagrams, electrochemical definitions, experimental methods in electrochemistry, batteries and accumulators, corrosion and protection against corrosion, electrochemical kinetics, electrochemistry of semiconductors, and modern electrochemical methods in analytical chemistry. The papers are written in French, German, and English.

KORROSION 11. KATHODISCHER KORROSIONSSCHUTZ. Sponsored by the Deutschen Gesellschaft für Metallkunde. Verlag Chemie, Weinheim, West Germany, 1959. 229 pages, 5¾ by 8½ inches, bound. 30 DM. The book contains the 10 papers of a symposium on the subject of cathodic corrosion protection including historical development, theoretical principles, the concept of cathodic protection against both fresh and salt water, underground corrosion of both piping systems and cables, stray-current corrosion, and measurement techniques. A bibliography of over 500 references since 1950, including many in English, is appended. These papers constitute the proceedings of a meeting held in Frankfurt, West Germany, in 1958.

LABOR-MANAGEMENT RELATIONS. By Charles Wiedemann. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N. Y., 1959. 142 pages, 5¼ by 7½ inches, bound. $3.75. Employee–employer relations are discussed from a highly practical point of view. Methods are presented for the solution of the problems involved in this relationship and new techniques are presented for management administration and policy in both union and nonunion operations. The importance of proper labor contract language is stressed, as are the effect that emotions have in labor relations, the problems of the union shop, and the effect of "right-to-work" laws and strikes.

MASERS. By J. R. Singer. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1959. 147 pages, 6 by 9¼ inches, bound. $6.50. This study of quantum mechanical amplifiers approaches the subject from both the classical and quantum mechanical points of view. A discussion of the ammonia maser and of the magnetic atomic beam system is followed by a section on an optically pumped frequency standard, and a description of electron paramagnetic resonance. Two-level masers are then treated with emphisis on their possibilities for millimeter and submillimeter wave generation, and numerical illustrations are employed in an examination of three-level cavity masers. The book concludes with the theory and experimental results of the traveling-wave masers.

MATHEMATICAL PROGRAMMING AND ELECTRICAL NETWORKS. By J. B. Dennis. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1959. 186 pages, 6 by 9¼ inches, bound. $4.50. A new approach to mathematical programming based on an analogy with electric networks is presented. It is shown that any d-c electric network made up of current sources, voltage sources, ideal diodes, and ideal transformers is equivalent to a pair of dual linear programs. A simple algorithm is developed for solving diode-source networks which is applicable to network flow problems including the transportation problem. A procedure for tracing the breakpoint curve of a diode-course-resistor-transformer network algebraically is derived, and it is used to obtain optimal solutions to general linear or quadratic programs.

MODERN ASPECTS OF ELECTROCHEMISTRY. Number 2. Edited by J. O'M. Bockris. Academic Press, Inc., 111 Fifth Ave., New York 3, N.Y., 1959. 416 pages, 6 by 8¾ inches, bound. $13. Beginning with interionic attraction in solution (a field of renewed interest because of significant progress toward the theory of concentrated solutions), the papers included discuss the physical chemistry of ion-exchange resins, molten electrolytes, and the mechanism of anodic processes at electrodes. A recent branch of electrochemistry dealing with the semiconductor–solution interface is the subject matter of the final paper.

NUCLEONICS FUNDAMENTALS. By D. B. Hoisington. McGraw-Hill Book Company, Inc. 330 W 42nd St., New York 36, N. Y., 1959. 410 pages, 6¼ by 9¼ inches, bound. $9.50. A broad view of the field of nucleonics is presented, with atomic and nuclear physics included to the extent necessary for an understanding of engineering applications. Topics discussed include atomic and nuclear structure, radioactivity, induced nuclear transformations, particle accelerators, radiation protection, instrumentation, nuclear fission, research reactors, nuclear and thermonuclear power, and the production of nuclear materials.

PARIS SYMPOSIUM ON RADIO ASTRONOMY. Edited by R. N. Bracewell. Stanford University Press, Stanford, Calif., 1959. 612 pages 6½ by 9½ inches, bound. $15. In this collection of papers reporting the latest advances in radio astronomy, the authors discuss moon reflections, radio emission from Jupiter and other planets, radio emission from the quiet and active sun, radio studies of the discrete radio sources (radio stars), radio evidence on the large scale structure of our own and external galaxies, cosmology, and the mechanisms by which solar and cosmic radio waves are generated. These papers constitute the proceedings of a symposium held in 1958 which was jointly sponsored by the International Astronomical Union and the International Scientific Radio Union.

THE PERFORMANCE AND DESIGN OF DIRECT-CURRENT MACHINES. By A. E. Clayton and N. N. Hancock. Third edition. Sir Isaac Pitman & Sons, Ltd., London, England, 1959. 516 pages, 6 by 8¾ inches, bound. 40s. In the revised edition of this text, which stresses the design aspects of d-c machinery, modifications and additions have been made throughout the book. In particular, the general treatment of the subject is now based on

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ENGINEERING Societies Library books, except bibliographies, handbooks, and other reference publications, may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint or a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, 29 W. 39 St., New York 18, N. Y.

the rationalized mks system of units, while the sections on control, special machines, and duplex lap windings receive more attention. In addition, the chapter on insulation has been completely rewritten and a supplementary chapter on eddy-current losses in deep armature conductors has been added.

PROGRAMMING FOR DIGITAL COMPUTERS. By Joachim Jeenel. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 517 pages, 6 by 9¼ inches, bound. $12. Intended for readers with no previous programming experience, this text presents a methodical approach to programming which is based on the representation of a program as a logical structure of standardized building blocks. This provides the programmer with a conceptual framework within which he can create a program more rapidly, and permits programs or different purposes and different machines to be represented in a uniform manner. Recent developments and specific topics covered include indirect addressing, randomized addresses, random-access storage, in-line processing, concurrent operations, and nonmachine languages.

THE PROPERTIES, PHYSICS, AND DESIGN OF SEMICONDUCTOR DEVICES. By J. N. Shive. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., 1959. 487 pages, 6¼ by 9¼ inches, bound. $9.75. This text bridges the gap between elementary presentations of semiconductor theory and highly theoretical treatments. In the first part, semiconductor devices are discussed from an empirical point of view. The nature, behavior, and uses of thermistors, varistors, photoelectric cells, and transistors are described, and fabrication techniques and typical application are considered. Part two discusses the solid-state electronics of semiconductors, and leads to a theoretical understanding of the physics underlying their operation. It provides a foundation for those interested in the physical and engineering features of semiconductor device design.

RADIOISOTOPES FOR INDUSTRY. By R. S. Rochlin and W. W. Schultz. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N. Y. 1959. 190 pages, 5¼ by 7½ inches, bound. $4.75. Numerous representative examples of radioisotope techniques used in a wide variety of industrial applications are described, with particular emphasis on those that are more recent. Sufficient material is included with each description so that the examples given may be extended to other situations. Topics included are gaging without contact, radiography and autoradiography, wear measurement, activation techniques, use of tracers in research and development, use of radioisotopes in manufacturing, and finding leaks with radioisotopes. In addition to uses, personnel safety and facilities for handling radioisotopes are discussed.

RUSSIAN–ENGLISH ATOMIC DICTIONARY. By E. A. Carpovich. Second edition. Technical Dictionaries Co., Box 144, New York 31, N. Y., 1959. 317 pages, 5¾ by 8½ inches, bound. $12. The new edition comprises over 23,000 Russian entries covering primarily the fields of nuclear science and technology; physics, including theoretical, atomic, and molecular physics; physics of solids; crystallography; and mathematics. Many terms from chemistry and chemical engineering are also included. In order to conserve space in this edition, most biomedical terms have been replaced by physical and mathematical terms.

SEMICONDUCTORS AND TRANSISTORS. By D. M. Warschauer. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1959. 267 pages, 6 by 9¼ inches, bound. $6.50. The physical principles underlying the behavior of semiconductors, transistors, and other solid-state devices are presented, as is their application to various circuits. Following the three fundamental transistor connections and their means of representation, oscillators, amplifiers, and switching circuits are discussed. In addition, information is included on the growth and purification of semiconductors, the fabrication of particular transistors, and nontransistor devices such as thermistors and phosphors. Emphasis is placed throughout on the fundamental ideas basic to all transistor theory and practice.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

SYMPOSIUM ON THE BASIC MECHANISMS OF FATIGUE, STP 237. The papers in this symposium clarify some of the mechanisms of failure such as dislocations, internal friction, crystalline and structural changes, and surface disintegrations. Various areas of observational levels are touched upon in discussing the mechanisms of fatigue. The papers also help to emphasize the statistical nature of the material behavior under cyclic loadings. The 128-page book may be ordered from American Society for Testing Materials (ASTM), 1916 Race St., Philadelphia 3, Pa. Price is $3.75 to nonmembers; $3 to ASTM members.

OTS REPORTS. The U. S. Office of Technical Services (OTS) has released the following reports for sale to the public: "ASTIA Subject Headings, 4th edition," *PB 151568*, 763 pages, $8, lists all subject headings used in the library system of the Armed Services Technical Information Agency (ASTIA), current to January 1959; Catalog No. 978 is a listing of commercial standards revised to July 1, 1959, which includes standards under 22 classifications, among them electrical and mechanical equipment, instruments and tools, and thermal insulation materials, and is available without charge from the Commodity Standards Division of the U.S. Department of Commerce; unclassified technical papers and discussions of a Government-sponsored seminar on advanced energy sources and conversion techniques are contained in *PB 151461*, "Advanced Energy Sources and Conversion Techniques, Nov. 1958, Vol 1," 256 pages, $4; and *PB 151360*, "A Double-Pulse Total-Absorption Fast Neutron Spectrometer (NBC Technical Note 1)," 27 pages, 75¢, describes an instrument developed at the National Bureau of Standards (NBS) for use in the 1- to 20-mev energy range. All of the foregoing reports are available from OTS, U. S. Department of Commerce, Washington 25, D. C.

EPOXY RESIN: MARKET SURVEY AND USERS' REFERENCE. The result of extensive research and a survey of 1,000 companies manufacturing, selling, and/or using epoxies, this report has 18 chapters devoted to use and cost experience in a particular industry, which serve to bring companies up to date on what others are doing in the field and to acquaint a nonuser with the possibilities offered by epoxies. The "Users' Reference" portion of the study contains a glossary, a list of periodical literature, and a selective listing of recommended reading by use area. Prepared by nine recent graduates of the Harvard Business School, the report is available at $18.50 from Materials Research, Box 363, Cambridge 39, Mass

RCA SEMICONDUCTOR PRODUCTS HANDBOOK, HB-10. Devoted exclusively to data on Radio Corporation of America (RCA) semiconductor devices including transistors and silicon rectifiers, this publication is a companion to the RCA Tube Handbook HB-3, and is available either in conjunction with the HB-3, or separately. Containing over 400 pages, the handbook has been compiled to meet the requirements of electronic equipment design engineers primarily, but will prove useful to all who have need for current technical information on RCA semiconductor devices. Data include intended uses, characteristics, typical operation, maximum ratings, terminal connections, commonly used curves plotted to scales for solving design problems, and mechanical dimension for the company's line of semiconductor devices. Subscription to both handbooks is $20 (foreign $21.50) and includes six binders, a complete set of data sheets on the company's electron tubes and semiconductor devices, plus service for one year. Subscription to the new HB-10 alone is $5 (foreign $5.50) and includes one binder, data sheets on semiconductor devices, plus service for one year. Write to: RCA, Semiconductor & Materials Division, Somerville, N. J.

EIA STANDARD. Copies of the following Electronic Industries Association (EIA) standard may be obtained through the EIA Engineering Dept., 11 W. 42nd St., New York 36, N. Y. (a minimum charge of $1 is made on all orders): *Rigid Coaxial Transmission Lines and Connectors—50 Ohms*, RS-225, a revision of TR-134, 80¢.

IEC STANDARDS. Two additions to the International Electrotechnical Commission (IEC) *Specification for Alternating-Current Circuit Breakers* (56-1 and 56-2) have been made available: 56-1-A, $3.60 a copy, contains recommendations for unit testing, by direct methods, of circuit breakers for making capacity and breaking capacity; and methods of determining inherent restriking voltage waveforms. The other addition, 56-3, $3.20 a copy, contains rules for normal load conditions. Both of these additions may be ordered through the American Standards Association (ASA) Dept. PR 96. Two recently published standards of the IEC are: *Recommendations for Ceramic Dielectric Capacitors Type I*, publication 108, $3.20 a copy, available from ASA Dept. PR 95, and *Recommendations for Aluminium Electrolytic Capacitors for General Purpose Application*, numbered 103, $3.20 a copy, available from ASA Dept. PR 71. The ASA is located at 70 E. 45th St., New York 17, N. Y.

TRANSISTOR MANUAL. The 4th edition of General Electric Company's manual contains 227 pages of completely rewritten information on transistors and their use in electronic circuits. Included in the 20 chapters is information on basic semiconductor theory, transistor construction techniques, biasing, switching characteristics, transistor radio servicing techniques, and several chapters on circuits. The book contains a revised and current listing of all American JEDEC-registered transistor types with their basic specifications and interchangeability information. The manual, priced at $1, may be obtained from the General Electric Company, Semiconductor Products Dept., Charles Bldg., Liverpool, N. Y.

SEMICONDUCTOR ABSTRACTS ON CARDS. Abstracts which cover more than 200 technical periodicals, U. S. Patents, conference papers, and new product releases, and are organized according to subject matter with extensive cross referencing, have been made available by Semiconductor Information Service. The semiconductor abstracts, on 3 by 5 cards, are available in any or all of the following categories: (1) physics of semiconductor materials, (2) metallurgy of semiconductor materials, (3) theory and fabrication of transistors, (4) circuit applications of transistors, and (5) other semiconductor devices (diodes, thermistors, photo devices, etc.). Subject and author indexes are also provided. The cost of the service is $30 a year per category or a total of $120 for the entire five categories. Orders may be sent to Semiconductor Information Service, 238 Main St., Cambridge 42, Mass.

NEMA STANDARDS. The following standards publications of the National Electrical Manufacturers Association (NEMA) have been printed, and copies are available for immediate distribution: *Industrial Control*, IC 1-1959, $6 per copy, which covers the rating, test and performance, manufacturing, and application of control devices, a-c general-purpose controllers, d-c general-purpose constant-voltage controllers, and definite-purpose controllers; and *Large Generating and Converting Apparatus*, LG 2-1959, 30¢ per copy, which covers frequency and phase converters and large hydraulic-turbine-driven generators. Both standards publications are available from NEMA, 155 E. 44th St., New York 17, N. Y.

U. S. GOVERNMENT PUBLICATIONS. *International Movement of Electric Storage Batteries*, No. C 41.2:St 7, 1959, 12 pages, 10¢, reports on the international movement of electric storage batteries in international trade. *International Movement of Electrical Transformers*, No. C 41.2:T 68, 1959, 12 pages, 10¢, offers a quantitative measurement of the production and distribution of electric transformers in international trade. Both publications may be ordered through the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

One NATIONAL brush grade conquered Contamination—Humidity—Low Loads!

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"Commutator trouble was a big expense item in this eastern pulp and paper plant," says "National" Carbon Brush Man, Morgan Henika. "And no wonder," continues Morgan, "paper machine drives worked on low loads in a highly humid, contaminated atmosphere!"

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New and Improved Products . . .

Miniature Coax Connector . . .

A versatile compression-type Hyfen gang connector for miniature coaxial cable has been developed that will accommodate three, five, or eight inserts snapped in from either front or back, with each insert accommodating up to 21 pins or sockets. The new plug and receptacle unit will connect *RG195U* cable and no. *24* shielded miniature coaxial cable, the inner connector having seven no. *32* strands. Connectors for other sizes of coaxial cable are under development. **Burndy Corp., Omaton Division, Norwalk, Conn.** *Circle 201 on the card.*

Three-Layer Zener Diode . . .

Principles of molecular engineering were used to combine in one tiny piece of silicon functions which normally require several individual components. The result is a high-precision voltage regulating device featuring self-compensating characteristics and yielding operating advantages in dynamic resistance, temperature coefficient, and noise. Called the Compensated Avalanche Diode, the component is expected to meet a growing demand for increasingly sophisticated electronic equipment used in missile control systems, scientific instruments, aircraft devices, industry controls, and electronic computers. **Shockley Transistor Corp., A Subsidiary of Beckman Instruments, Inc., Stanford Industrial Park, Palo Alto, Calif.** *Circle 202 on the card.*

Wheatstone Bridge . . .

The old bridge's awkward, tiresome plugs and blocks have been replaced with enclosed rheostat dials and high-quality selector switches in this newly designed instrument. The result is faster and easier operation by merely turning the dials and taking a direct reading from the windows above each dial. Unlike its predecessor, the Anthony Pattern Wheatstone Bridge that has been a standard for accurate d-c resistance measurements since 1903, this revised model provides complete guarding against errors caused by humidity assuring an accuracy of ±0.01% up to 1 megohm and

Courtesy Leeds & Northrup

±0.02% up to 100 megohms. **Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.** *Circle 203 on the card.*

Permanent Magnet Provides High Energy Values . . .

The Hyflux Alnico *V-7* represents an important breakthrough in the field of permanent magnets. The component will be useful where applications call for greater energy-per-unit-weight/volume or equal energy from a lighter/smaller magnet. Increased energy values are due to the material's high degree of crystal orientation. Because orientation and magnetization must be straight, the most common magnet shapes are likely to be cylinders, rectangles, and other prisms, including conic or pyramidal frustums. Applications include lightweight ground and airborne generators, alternators, recording instruments, oscillographs, magnetometers, and galvanometers. **The Indiana Steel Products Co., Valparaiso, Ind.** *Circle 204 on the card.*

Electronic Fault Finder . . .

Developed in co-operation with the North of Scotland Hydroelectric Board, this detector employs the principles of radar pulse reflections to facilitate rapid location of faults occurring on 132-kv grid lines. The reflection in this instance is caused by any local variation in line characteristic impedance. The distance to the fault can be found by measuring the time interval between the sending of the pulse and the reception of its reflection. **Ferranti Ltd., Edinburgh, Scotland.** *Circle 205 on the card.*

Motor Stator Compound . . .

This epoxy compound protects electric motor stator windings against moisture,

dirt, abrasives, chemicals, and other contaminants. Hysol *10-55* is a 2-component system which is mixed 1 to 1 by volume. Its excellent thixotropic characteristic allows the use of a simple "butter technique" in its application, even on hot stators. No dripping or run-off is encountered during application or cure. Its flexibility prevents cracking during temperature changes. The usual curing oven temperatures are used for preheating the motor and for curing the compound. **Houghton Laboratories, Inc., Olean, N.Y.** *Circle 206 on the card.*

28-Kv Cable . . .

Increasingly higher voltages used in modern transmission systems have created a need for cable with substantially thicker insulation to sustain the increased physical and electrical demands placed upon it. This new 28-kv power cable has a $^{33}/_{64}$-inch thick butyl-rubber insulation, a $^{7}/_{64}$-inch neoprene outer jacket, and weighs 3.6 pounds to the foot. It has been tested at 120 kv a-c for 5 minutes and 150 kc d-c for 15 minutes without any physical or electrical deterioration. **H. K. Porter Co., Inc., National Electric Division, Porter Building, Pittsburgh 19, Pa.** *Circle 207 on the card.*

Ultraviolet-Sensitive Vidicon . . .

Believed to be the first tube constructed with a fused-quartz faceplate, this small developmental television camera tube will be used for medical and biological research in closed-circuit television systems. Living cells are normally transparent to ordinary light. The fused-quartz faceplate of the vidicon permits observation of living cell specimens that have been irradiated to ultraviolet light. Known as developmental *C-73439*, the tube has a 1 inch diameter faceplate and will be used with the ultrascope, a new microscope that allows direct visual focusing of an image under ultraviolet light. **Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N. Y.** *Circle 208 on the card.*

Servo Recorders . . .

Featuring high sensitivity, fast response time, and superior interference rejection capabilities, this new line of instruments will be offered in wide or narrow chart and single or dual channel models. Good filtering and careful design provide a high order of rejection to common-mode d-c and to all types of 60 cps interference. Featuring a step span response of less than 0.5 seconds on a 4.5 inch chart, the in

(Continued on page 22A)

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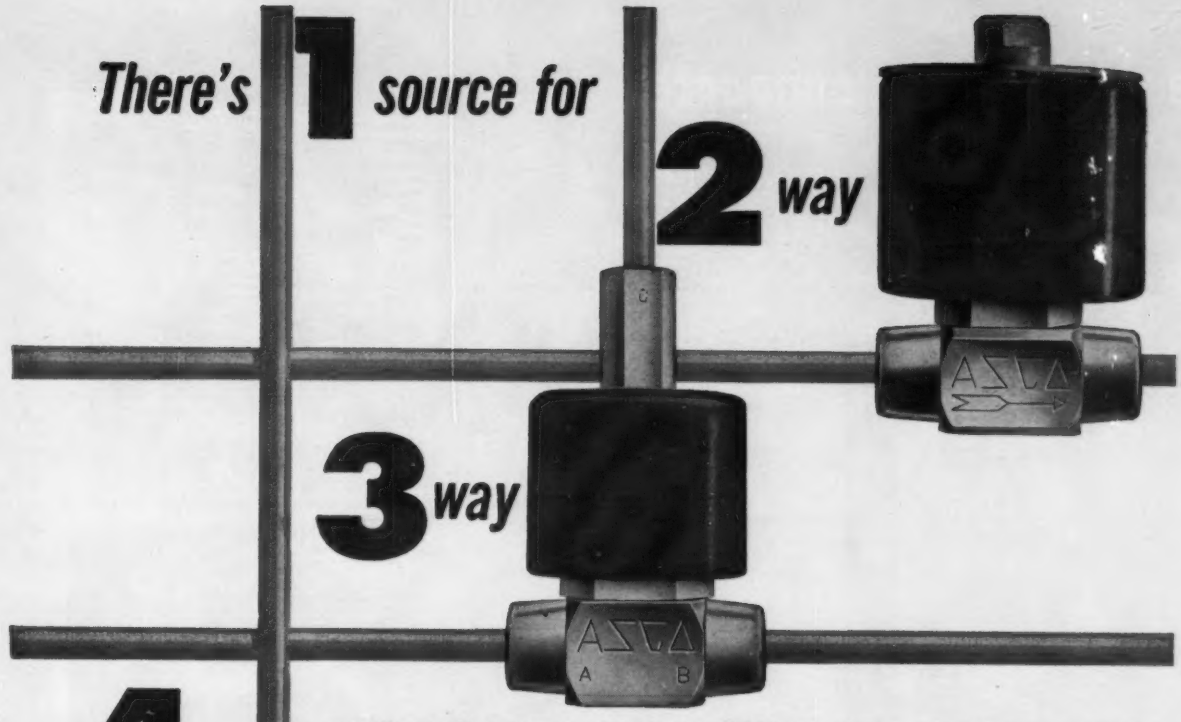

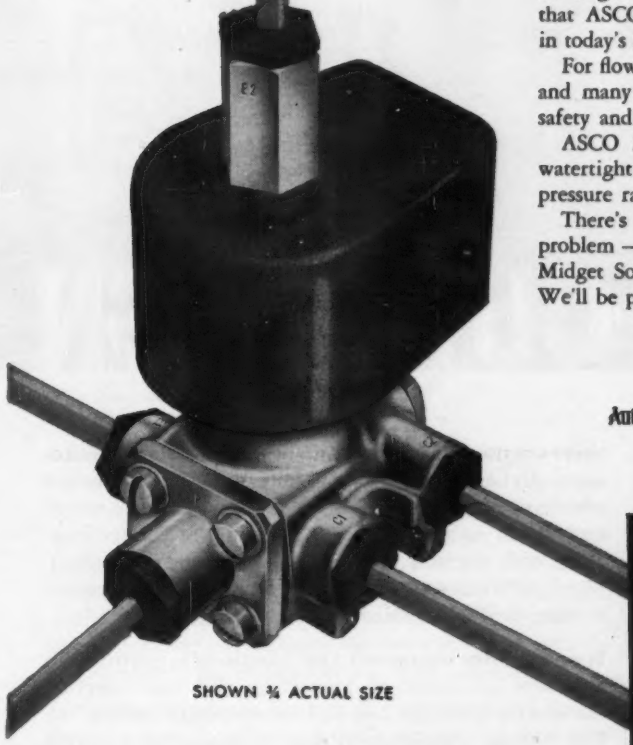

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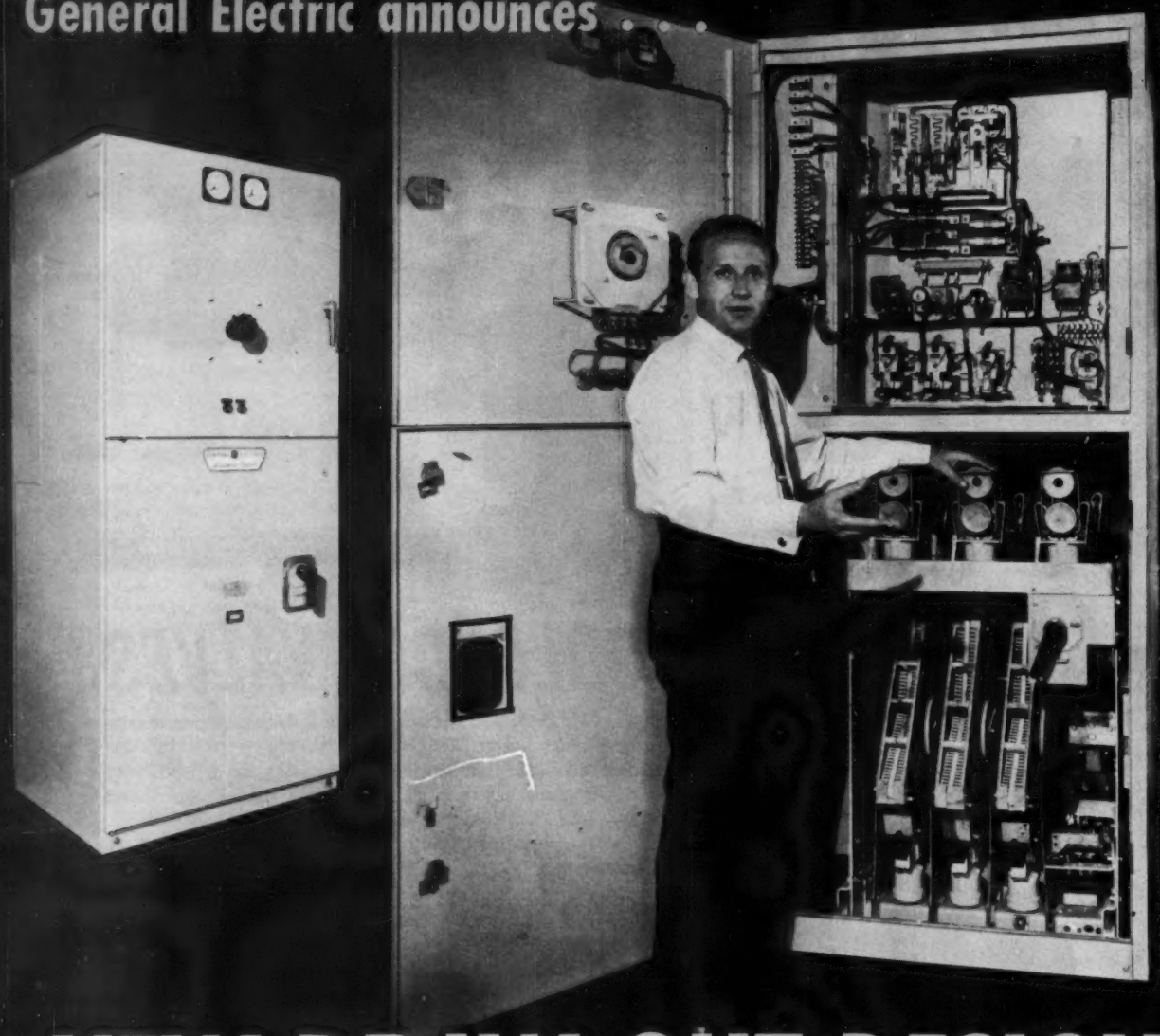
General Electric announces . . .



NEW DRAW-OUT DESIGN

From General Electric comes the all-new draw-out Limitamp control—today's most advanced medium-voltage motor starter. Designed for the control of a-c motors rated 2300 through 4600 volts and up to 3000 hp, this new air-break starter has broad application throughout industry.

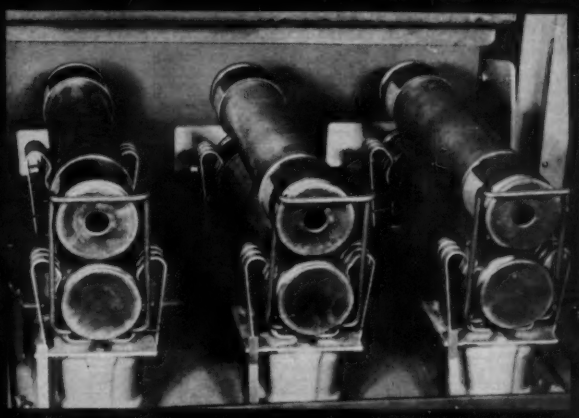
Since its introduction in 1941, Limitamp control has established a reputation for being first with the design features that add up to major user benefits. And, today's all-new Limitamp control follows this pattern with a host of design innovations that make for:

Faster installation: When you're ready to roll in the contactor—it can be done easily by one man. And, there are no connections to make—they are made automatically as the contactor rolls into place. There's plenty of space inside the panel for pulling the motor and power cables . . . and making the connections. And, with the new design, floor sills have been eliminated. This means no more grouting, no expensive cement work, simplified lineup with other panels.

Simpler, safer operation: One handle now controls the complete operation of connecting and disconnecting the starter from the bus and mechanically locking the high-voltage compartment door. A unique interlocking system protects the unit from misuse.

Superior protection: General Electric's new Limitamp

INSTALLS IN HALF THE TIME—Draw-out air break contactor, roomy isolated cable compartments, and increased working space help simplify installation.



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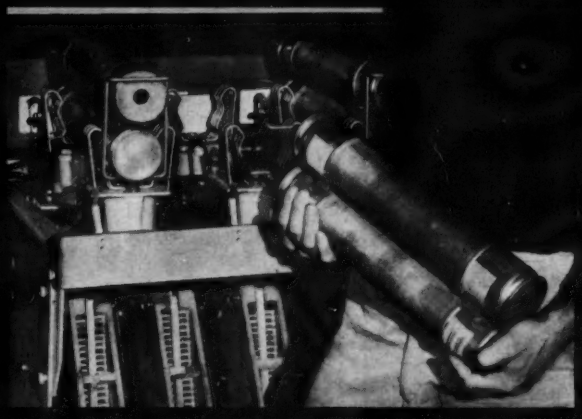

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control utilizes fast-acting current-limiting fuses, ambient-compensated overload relays, and a high-voltage contactor to provide the most "positive" protection for your motors. Proved EJ-2 fuses interrupt a fault in the first ½ cycle, thus reducing damage to valuable motors. The performance of the completely coordinated design has been exhaustively tested in General Electric's high-voltage laboratory to provide the most reliable equipment for your application.

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Sorensen MVRP's easily replace most ordinary plate and filament transformers. They increase circuit reliability, extend component life by regulating 6.3 vac and 5.0 vac filament voltages as well as plate voltage. Write for complete data. Sorensen & Company, Richards Ave., South Norwalk, Connecticut.

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Input, all models: 100-130 vac, 60 cps, single-phase.
Regulation: All windings regulated ±3.0% unless otherwise specified.
Output voltage tolerance: ±7.0% all windings.

Model Number	D-c Input to Filter* From Regulated Center-Tapped H-v Winding	Regulated Filament Windings	
		6.3 vac	5.0 vac
MVRP-40	275 vdc at 50 ma.	2.5 amps, ct	2.0 amps
MVRP-70	385 vdc at 110 ma.	3.0 amps, ct	2.0 amps
MVRP-185	380 vdc at 250 ma.	Two windings: 4.0 amps plus 8.0 amps unregulated	3.0 amps

*Nominal value taken at output of type 5Y3GT rectifier for Models MVRP-40 and MVRP-70 and type 5U4GA/GB for MVRP-185. Regulated 5.0-volt filament winding for the rectifier tube must be used for ±3.0% guaranteed regulation of plate voltage output.

Separate capacitor furnished with each transformer.
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Sorensen
A SUBSIDIARY OF RAYTHEON COMPANY

CONTROLLED POWER PRODUCTS

. . . the widest line lets you make the wisest choice

NEREM '59 Commonwealth Armory, Boston, Nov. 17, 18 & 19
Circle 14 on the card.

New & Improved Products

(Continued from page 18A)

strument has a power sensitivity of better than 10^{-17} watts with off-balance input resistance of 4 megohms and a standard electrical span of 2.5 millivolts d-c. **Texas Instruments Inc., 3609 Buffalo Speedway, Houston 6, Texas.** *Circle 209 on the card.*

Printing Demand Meters . . .

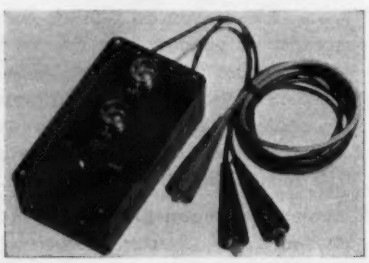
Some of the improved features to be found in the redesigned *PD55F* and *PD57F* demand meters are an improved printing system, a universal-mounting case with drawout construction, new impulse and reset contact assemblies to reduce arcing, and easier tape servicing. Additional built-in features include a relay amplifier and heater, a demand-dial pointer showing at all times the printing counter's stage of advance from the zero position, and a pointer that displays maximum advance of the printing counter during the previous interval since the pointer was last set manually. **General Electric Co., Schenectady 5, N. Y.** *Circle 210 on the card.*

Light Intensity Calibrator . . .

Utilizing silicon cells, this light calibrating instrument not only measures the intensity of solar and tungsten radiation but also the color temperature of the light. Highly accurate, the instrument can be used to measure all "black body" radiation other than ultraviolet and fluorescent. One specific application will be to measure the color temperature of molten metal in forging and metal working. The instrument is capable of measuring light intensity radiation from 1 to 10,000 foot-candles, color temperatures from 1,800 to 3,200 K, and spectral sensitivity from 4,000 to 11,500 angstroms. **Hoffman Electronics Corp., 3761 S. Hill St., Los Angeles 7, Calif.** *Circle 211 on the card.*

Portable Phase Sequence Indicator . . .

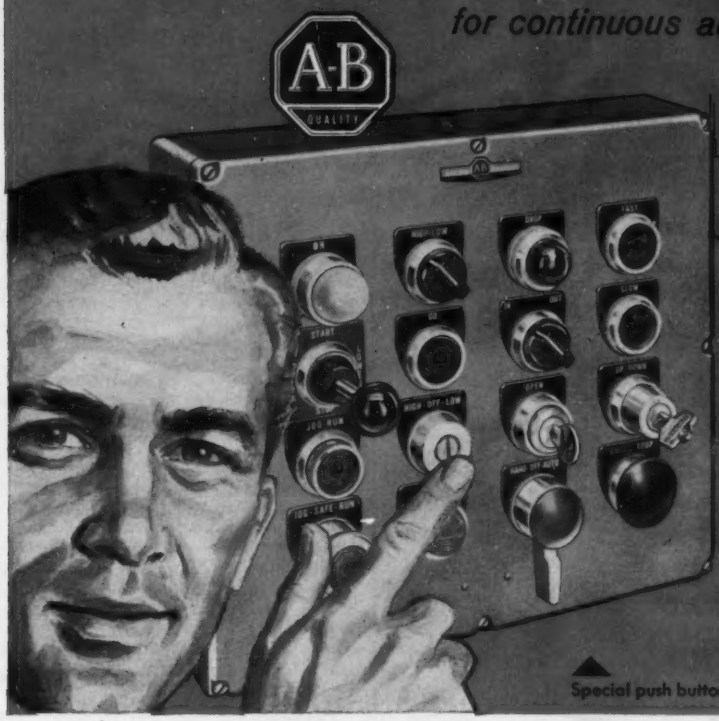
A pocket portable instrument for indicating phase sequence in 3-phase power systems has a switch for adjustment to 120, 240, and 480 volts. The three insulated test leads are connected at random to the 3-phase conductors. When the lamp marked



(Continued on page 24A)

AUTOMATION BEGINS HERE

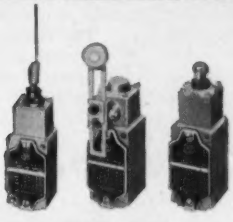
. . . Insist on Allen-Bradley accessories for continuous automatic production



In this broad line of Allen-Bradley accessories, each and every unit carries the traditional A-B trademark of *quality* that stands for trouble free operation. Rugged construction, and maintenance free, silver alloy contacts provide the reliability that is essential to the continuous operation of *your* automatic production machines.

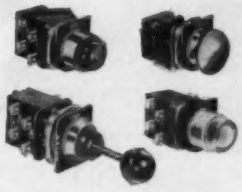
Profit from the experience of the leading machine tool builders . . . insist on Allen-Bradley *quality* motor control *all the way!*

Special push button panels can be assembled to your specifications.

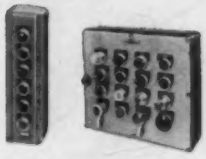


OILTIGHT LIMIT SWITCH
Bulletin 802T with sealed heads and bodies. Various operators.

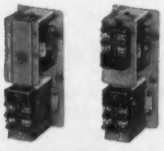
PRECISION LIMIT SWITCH
Bulletin 802 oiltight. Responds to very small operator travel.



OILTIGHT CONTROL UNITS
Bulletin 800T. Choice of push buttons, lights, and switches.

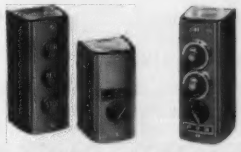


OILTIGHT CONTROL STATIONS
Bulletin 800T for up to 16 units in die cast aluminum enclosure.

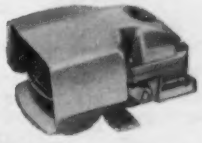


PNEUMATIC TIMERS
Bulletin 849. Reliable and accurate. For on-delay or off-delay.

OILTIGHT PRESSURE CONTROL
Bulletin 836. For hydraulic systems with pressures to 5000 psi.



STANDARD DUTY PUSH BUTTONS
Bulletin 800. Up to three units, also pilot lights and switches.



FOOT SWITCH
Bulletin 805. In rugged die cast housing for toughest service.

ALLEN-BRADLEY
Member of NEMA

QUALITY MOTOR CONTROL

Allen-Bradley Co., 1301 S. First St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

For more information circle 15 on reader service card

New & Improved Products

(Continued from page 22A)

"ABC" glows, the sequence is as designated by the test leads. If the lamp marked "CBA" glows, the phase sequence is the reverse of the lead designation. **Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.** *Circle 212 on the card.*

Data-Processing Machine . . .

This conversion unit is designed to sample analog voltage information, digitize it, and then print seven channels of data at the rate of three channels per second. Visual output is by means of Nixie lamp banks supplemented by a printed paper tape or an IBM card for permanent data recording. Basic applications include computer output monitoring, refinery and pipeline logging, monitoring data transmission equipment, and recording information from strain gauges and pressure converters. **The Gerber Scientific Instrument Co., 89 Spruce St., Hartford, Conn.** *Circle 213 on the card.*

Portable Universal Hoist . . .

No larger than a vacuum cleaner, and weighing only 47 pounds, this portable nonfouling universal hoist can be operated electrically or manually and has a lifting capacity of 6,000 pounds. Design compactness is achieved by enclosing the motor inside the cable drum and through the use of compound differential planetary gearing. Power is supplied by a 3-phase, 400-cycle reversible a-c motor. A modified version is also available with a 24-volt d-c or 60-cycle a-c motor. **The Garrett Corporation's AiResearch Manufacturing Division of Los Angeles, 9851 Sepulveda Blvd., Los Angeles, Calif.** *Circle 214 on the card.*

Radiation Testing Chamber . . .

The first of a line of environmental chambers that will test products and materials while undergoing radiation exposure has an adjustable temperature range from +130 F to −80 F. Altitude can be controlled from sea level to 100,000 feet. A steam vapor generator provides 100% relative humidity in the chamber. The water supply reservoir mounted directly on the unit makes the unit completely portable. Radiation is accomplished by a 1-inch diameter nonmetallic tube that penetrates through the chamber and extends 6 inches on each side. **Cincinnati Sub Zero Products, 3932 Reading Rd., Cincinnati 29, Ohio.** *Circle 215 on the card.*

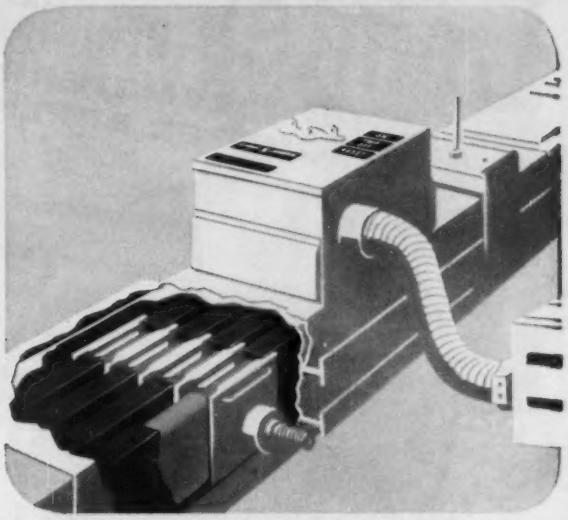
Cleanliness Tester . . .

How clean is clean? The *CMI* tester makes it possible to assign numerical values to surface cleanliness where nonbonded soils are involved. For example, it will measure smut residue after pickling

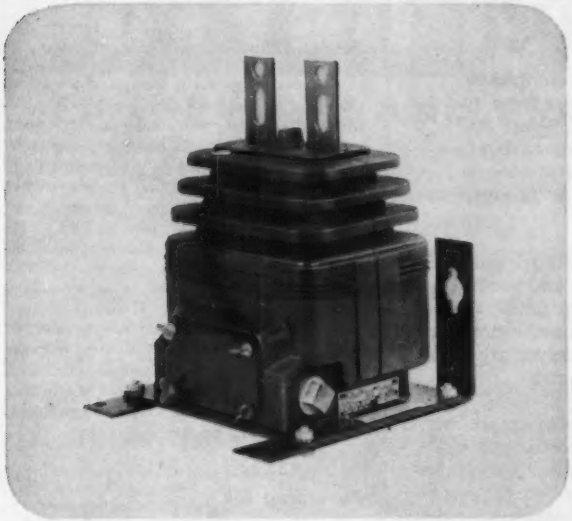
(Continued on page 26A)

ENJAY BUTYL . . . THE IDEAL RUBBER FOR INSULATION AND JACKETING

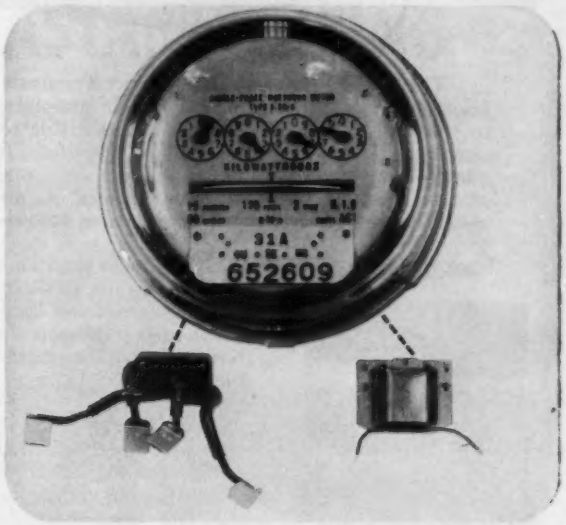
RESISTANCE TO MOISTURE — The mechanical water absorption of Butyl insulation in 90° C. water is only about *one-sixth* that of oil base compounds. This is an important characteristic for insulations to be used in direct burial, underground conduits, etc.



RESISTANCE TO HEAT — Because of superior resistance to deterioration caused by heat and traveling arcs, Butyl helps make possible the first low voltage busway system (600 v and below) designed specifically for aluminum conductors.



RESISTANCE TO WEATHERING — Butyl's inherently higher resistance to sunlight, moisture and weathering makes it the ideal material for this indoor-outdoor transformer casing. Integral molding of external parts provides reliable weatherproof insulation.



RESISTANCE TO AGING — Butyl is virtually ageless. That's why it was selected to stand up to sunlight and ozone in outdoor watt-hour meters. Butyl provides dependable insulation and must resist all weather conditions for 30 years.

Enjay Butyl is the best of the vulcanizable rubbers, either natural or synthetic, from the standpoint of electrical and dielectric properties, ozone and corona resistance, heat and moisture resistance, and long aging. Find out how versatile, low cost Butyl can help improve your products. For more information call or write your nearest Enjay office.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY BUTYL

ENJAY COMPANY, INC., *15 West 51st Street, New York 19, N. Y.*

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

For more information circle 17 on reader service card

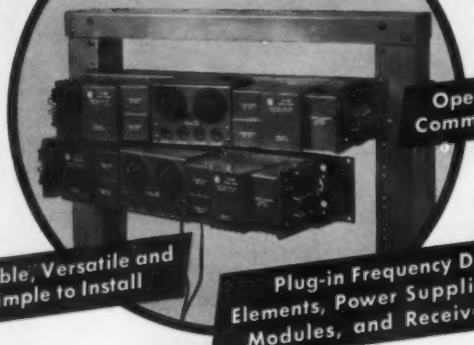
REMOTE INSTRUMENTATION & CONTROL

U.S. PAT. 2,844,720

Comtel® Transistorized Modular Terminal Units for TELEMETERING and CONTROL APPLICATIONS

Designed for Continuous Duty

Compatible with all Telemetering End Equipment



Operates over any Communication Circuit

Reliable, Versatile and Simple to Install

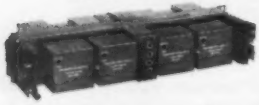
Plug-in Frequency Determining Elements, Power Supplies, Transmitter Modules, and Receiver Modules.

The Model 1220 and 1220A Carrier Terminals are completely transistorized and may be operated from station batteries from 12 to 130 DC. Plug-in power supply is available for 115-volt AC operation. All components, including amplifiers, frequency determining components, and power supplies are contained in plug-in modules, and may be readily interchanged. As many as 22 high-speed channels are available between 300 to 3000 cps.

MODEL 1220

The Model 1220 Terminals are normally used in telegraph applications and provide all necessary carrier and loop jack fields, as well as loop current controls. Two transmitters, two receivers, or a transmitter receiver are available on a single 5¼" x 19" chassis.

MODEL 1220A



The Model 1220A Terminals are normally used in telemetering and control applications. The individual modules are mounted on a swing-out chassis and are readily accessible. Four transmitters, four receivers, or two transmitter receivers are available on a single 3½" x 19" chassis.

WE CAN HELP YOU — Our Applications Department is ready to assist you in your control, telemetering or communications problem.

SEND FOR TECH. DATA

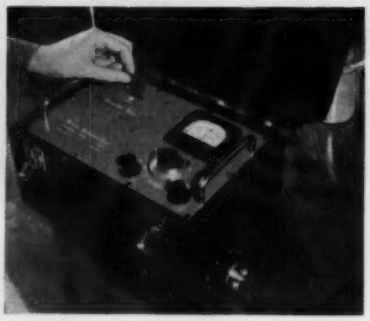
For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

Radio Frequency LABORATORIES, INC. Boonton, New Jersey, U. S. A.

Circle 18 on the card.

New & Improved Products

(Continued from page 24A)



of steel, evaluate detergents and oils used on cold mills, and determine annealing furnace performance and the efficiency of electrolytic and alkaline cleaning lines. Plating, lithographing, organic coating, and adhesive bonding are other typical applications where absence of foreign matter is vital to the success of the operation. The tester has a linear scale from 0 to 1,000, where 1,000 indicates absolute cleanliness. Accuracy of one part in a thousand is possible by a 10-turn potentiometer in the balancing circuit. **Branson Ultrasonic Corp., 40 Brown House Rd., Stamford, Conn.** *Circle 216 on the card.*

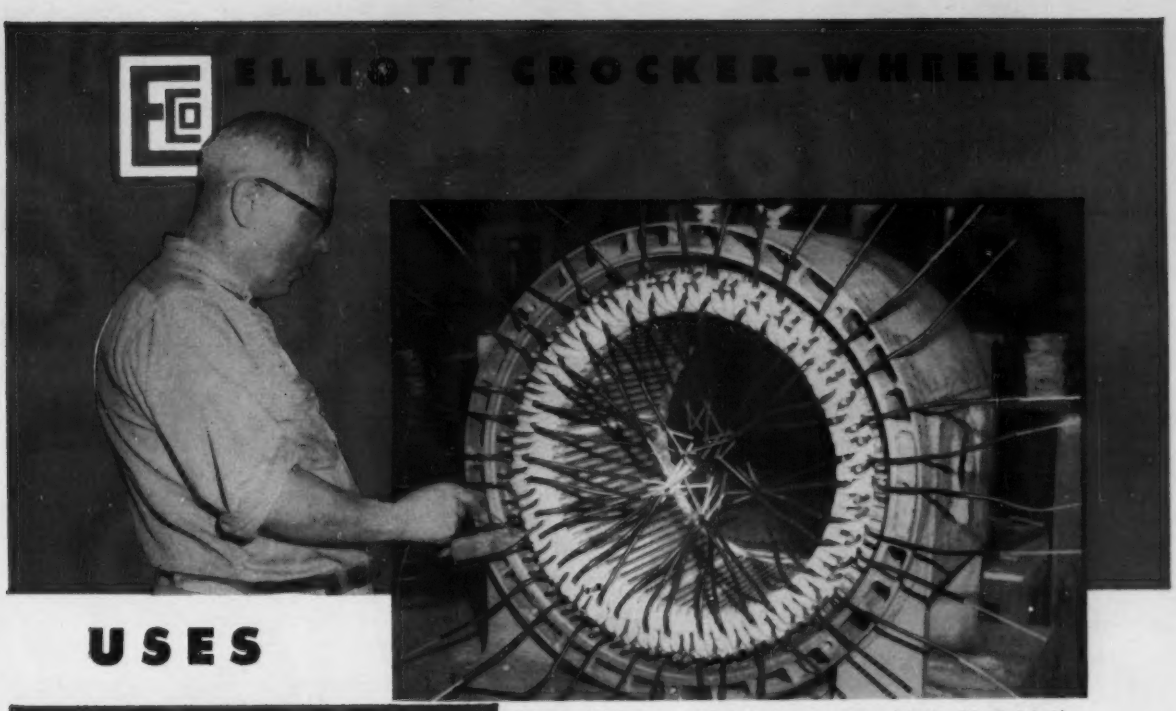
Power Transformers . . .

Several important design changes in this line of network and secondary unit substation transformers have recently been made. A novel type of panel box radiator has replaced a tubular cooling system with subsequent better overload capacity while a vertical top charger placed alongside the core and coil assembly has resulted in reduced over-all height and unit space requirements. Combining secondary 480Y/277 and 208Y/120 in the same secondary substation transformer by means of tapping the 480-volt winding offers valuable dual unit economic advantages without creating magnetic unbalance in the coils. **Queensboro Transformer & Machinery Corp., 115-25 Fifteenth Ave., College Point, N. Y.** *Circle 217 on the card.*

Recording Ink . . .

Recording instruments using capillary-type writing capsules can cause the loss of valuable test results if there is clogging, skipping, missing, or smearing due to poor ink. Especially compounded for ball-pen recording instruments, this new ink virtually eliminates impurities or air bubbles which are the major causes for poor pen performance. Other advantages are instant starting after long idle periods, operation at high ambient temperatures, light point pressure, excellent photocopying characteristics, a wide choice of colors, and good high or low chart speed performance. **Formulabs, Inc., Escondido, Calif.** *Circle 218 on the card.*

(Continued on page 28A)



Isolastane is Natvar's new elastomeric isocyanate-type coating for Fiberglas® braid and tape. Isolastane tubing being installed on coil leads and connectors of a larger AC motor.

USES NATVAR ISOLASTANE® TUBING

TO INSULATE AND PROTECT MOTOR LEADS

The Crocker-Wheeler plant of Elliott Company builds a wide range of electrical motors in sizes up to 500 hp. Natvar Isolastane tubing is widely used on both large and small AC induction motors.

Isolastane tubing is especially suitable for protection of motor coil leads and connectors because of its uniformly high dielectric value, mechanical strength, and resistance to all oils and solvents commonly used in insulating applications.

When you need flexible insulating materials with good physical and electrical properties and exceptional uniformity, it will pay you to get in touch with your distributor or with us direct.

Natvar

Natvar Products

- Varnished cambric—sheet and tape
- Varnished canvas and duck—sheet and tape
- Varnished silk and special rayon—sheet and tape
- Varnished papers—rope and kraft—sheet and tape
- Varnished, silicone varnished and silicone rubber coated Fiberglas®—sheet and tape
- Slot cell combinations, Aboglas®
- Isoglas® sheet and tape
- Isolastane® sheet, tape, tubing and sleeving
- Vinyl coated and silicone rubber coated Fiberglas tubing and sleeving
- Extruded vinyl tubing and tape
- Styroflex® flexible polystyrene tape
- Extruded identification markers

*T.M. (Reg. U.S. Pat. Off.) OCF Corp.

We will be very happy to supply information on any of our products on request.

Natvar Isolastane tubing, as applied to these AC field coil leads flexes easily and gives ample electrical and mechanical protection.

Isolastane tubing, applied to coil leads of these smaller NEMA frame motors will withstand continuous operating temperatures up to 155°C (class F) and is extremely tough and resilient and resistant to abrasion.

NATVAR CORPORATION

FORMERLY THE NATIONAL VARNISHED PRODUCTS CORPORATION

TELEPHONE FULTON 8-8800

CABLE ADDRESS NATVAR: RAHWAY, N. J.

203 RANDOLPH AVENUE • WOODBRIDGE, NEW JERSEY

For more information circle 19 on reader service card.

*

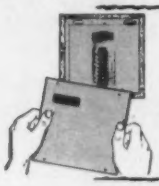
GTC

*an effective, economical industrial communication system designed to provide swift and sure voice communications regardless of distance or surrounding noise conditions.

. . . THE UNITIZED COMMUNICATION SYSTEM . . .

COMPLETELY TRANSISTORIZED AND DESIGNED TO MEET THE CRITICAL REQUIREMENTS OF INDUSTRY

1. An effective, economical industrial communication system designed to provide swift and sure voice communication under adverse environmental conditions such as extremes of temperature and noise.



2. All amplifiers are "plug-in" contributing greatly to ease of installation and MAINTAINABILITY.

3. Transistors and rugged, industrial type components are used throughout. No vacuum tubes or "entertainment" type components of any kind are employed.

4. Central Control cabinet is eliminated thus reducing space requirement to a minimum.

5. ULTRA SIMPLE WIRING PLAN (no shielded cables) and UNITIZED EQUIPMENT with integral terminal facilities make for EASY LOW COST INSTALLATION and LATER EXPANSION.

* GAI-TRONICS TRANSISTORIZED COMMUNICATIONS

GAI-TRONICS
CORPORATION
Dept. B
READING, PENNA.
A SUBSIDIARY OF GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

GTC is extremely flexible in application. Write today for a copy of our completely illustrated, descriptive booklet and name of nearest representative.

Circle 20 on the card.

New & Improved Products

(Continued from page 26A)

Mobile Oil Purifier . . .

Mounted on a 2-wheel trailer, this mobile oil purifying machine will press filter 1,800 gallons of transformer and circuit breaker oil per hour. The entire unit comprises an air compression tank to check leaks, an oil storage tank, piping and hoses, a portable electric filter paper drying oven, and a portable 35-kv oil test set. **Northeastern Engineering, Inc., Switchgear Dept., P. O. Box 150, Manchester, N. H.** *Circle 219 on the card.*

Redesigned Megohmmeter . . .

That old workhorse of the electrical industry, the hand-crank megohmmeter, has received a design overhauling with this new Series *B* line. Basic improvements include the use of a generator with a 39-bar armature in place of the conventional 2 or 4 bar unit, skewering of the armature windings to prevent "slot lock," and needle bearings. The use of neon lamps to light the meter dial also helps stabilize the generator output against random "leakage bursts." Other improved features include fast charge and discharge switch, recessed terminals to prevent cracked binding parts, and a nonskid base. **The Winslow Co., 701 Lehigh Ave., Union, N. J.** *Circle 220 on the card.*

UHF Induction Heater . . .

Operating at 120 mc, the highest frequency yet obtained with a commercial machine, this device shows superior ability for heating highly resistive materials like silicon, boron, titanium boride, germanium, ferrites, and yttrium-iron-garnet. Since the unit also operates in the dielectric frequency range, it can also be used to seal polyethylene ampoules and other nonconductive materials with speed and excellent spot-heat application. **Radio Frequency Co. Inc., 44-46 Park St., Medfield, Mass.** *Circle 221 on the card.*

VHF Transceiver . . .

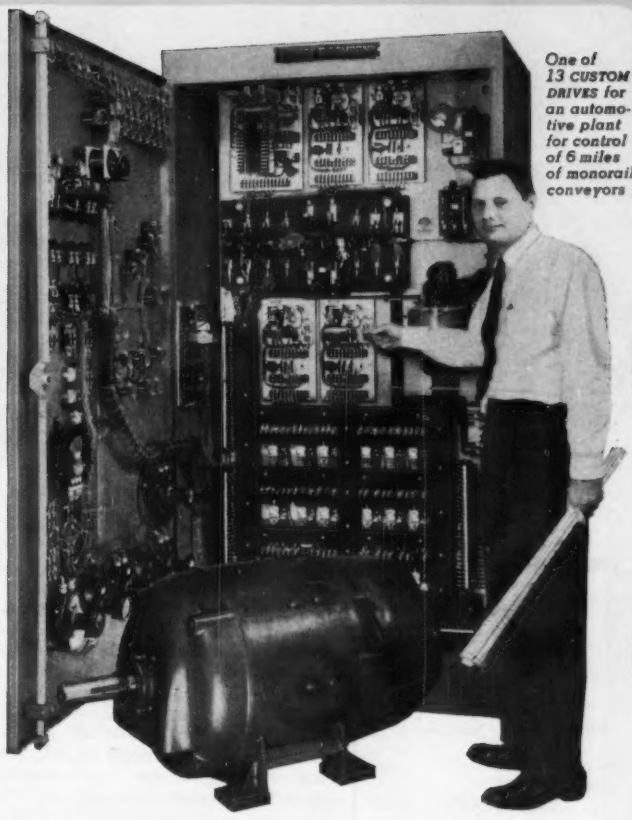
Weighing only 12.6 pounds and designed for panel mounting in light and medium aircraft, this 360-channel vhf transceiver will provide pilots with an output of 6 watts minimum. The equipment covers the 118.0- to 135.95-mc range with 50 kc spacing. It also uses digital tuning, and features single channel simplex/double channel simplex. **Collins Radio Co., P. O. Box 1891, Dallas 21, Texas.** *Circle 222 on the card.*

Motor Cleaner . . .

Chemically related to the fluorinated hydrocarbon compounds widely used as refrigerants and aerosol propellents, Freon

(Continued on page 30A)

Handle Any Adjustable-Speed Job with One of these Square D "packages"*



One of 13 CUSTOM DRIVES for an automotive plant for control of 6 miles of monorail conveyors

ELECTRONIC DRIVES

employ advanced designs using more static elements and less tubes. Fail-safe circuits prevent motor runaways. Available in sizes from 1/20 H.P. through 40 H.P.

STATIC POWER MAGNETIC AMPLIFIER DRIVES

provide top reliability and simple maintenance. Save both floor space and weight as compared to conventional drives. Available in sizes through 400 H.P.

MOTOR-GENERATOR DRIVES

use static regulators and rectifiers for simplified maintenance. Rugged, heavy-duty components are provided in each drive. Available in sizes through 400 H.P.

CUSTOM DRIVES

for every possible adjustable-speed requirement can be designed for you using combinations of the above units, plus special units, with accuracies to fractions of 1%. The answer to your adjustable speed problem is as near as your Square D field office.

** a Square D "package" includes the power conversion unit, operator's station, and drive motor*

No matter what adjustable-speed requirements you may have, you can select a Square D drive to meet them exactly. Moreover, every component—from control to drive motor—is subjected to a complete electrical test, and the entire drive is test-run at the factory to assure top performance on the job.

***Write** for complete details. Ask for Adjustable-Speed Bulletin. Square D Company, 4041 North Richards St., Milwaukee 12, Wis.*

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

For more information circle 21 on reader service card

New dimensions
in Communications

6. **EXPLORATION OF ELECTRICAL EMPATHY**

In its long-range preparations for the supercommunications network of tomorrow, General Telephone Laboratories has many new and interesting concepts and techniques under continuous study.

One area of investigation is centered on advanced methods of automatically projecting simulated conditions into complex telephone networks and obtaining read-outs on equipment status.

A recently developed system automatically routines subscriber lines, toll ticketers and exchange switching equipment with a series of programmed tests, each of which is fed back to a read-out printer. Failures or faults are instantly registered by visual and audible alarms.

Entry into the advanced forms of electronic switching systems now under development will require Automatic Routiners with a greater sophistication of circuitry.

This is one of the many challenges open to the creative mind at General Telephone Laboratories.

If your experience and interests are centered in solid-state circuitry, digital data transmission, computer circuitry, memory systems or electronic packaging, we have permanent positions to offer. For an appointment, write in confidence to Mr. Robert Wopat, President, General Telephone Laboratories, 100 Wolf Road, Northlake, Illinois.

General Telephone Laboratories GENERAL SYSTEM

Circle 22 on the card.

New & Improved Products

(Continued from page 28A)

solvents are finding broad applications in cleaning electric motors. Small motors may be cleaned effectively by immersing and operating them in a bath of liquid Freon-TF solvent which, unlike the refrigerant grades, boils at a relatively high temperature of 118 F. Larger electric motors can be cleaned without complete dismantling by simply spraying the solvent on the motor windings. This solvent may also be used to clean delicate, close tolerance electronic parts since it leaves no detectable residue. **E. I. Du Pont de Nemours & Co., Wilmington Del.** *Circle 223 on the card.*

Easy Zeroing of Synchros . . .

Designed to relieve the tedium of zeroing synchros and resolvers in servo systems without the necessity of switching component leads, this product conforms to BuOrd's new specification MIL-S-20708A. The *EZ* Indicator is intended for system manufacturing operations where large quantities of many different synchro types must be rapidly zeroed. **Theta Instrument Corp., 48 Pine St., East Paterson, N. J.** *Circle 224 on the card.*

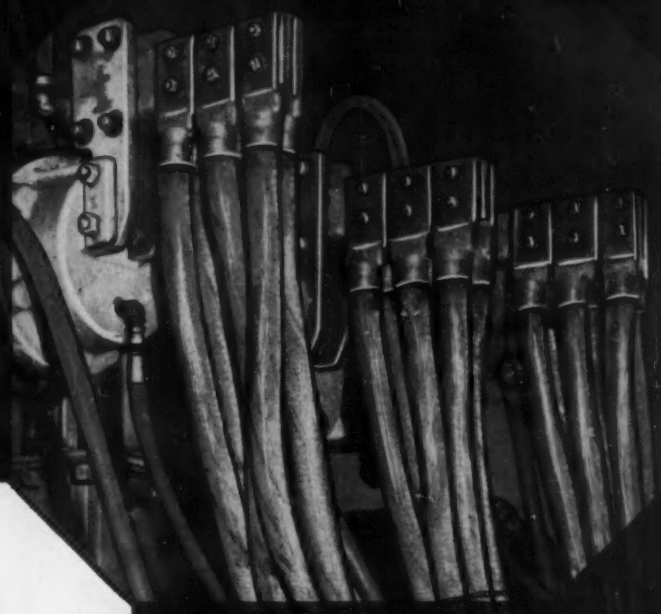
Tape Preparation-Editing Console . . .

A tape preparation and editing console which automatically verifies and duplicates paper tapes consists of a numerical keyboard, a control and comparison section with 6-digit decimal readout, two tape readers, and one tape perforator. Key features are tape-to-tape duplication and verification at 60 characters per second, keyboard visual display and shift register to eliminate copying errors, automatic error alarm, and tape corrections without over-punching or splicing. Tape verification is accomplished either through keyboard data re-entry or through comparison of tapes in the two read stations. Comparison is automatic within the console. **Tally Register Corp. 5300 14th Ave., N.W., Seattle 7, Wash.** *Circle 225 on the card.*

Automatic Controlled Rectifiers . . .

Fast, stepless, continuous voltage or current control is made possible with this new line of regulators designed for laboratory, plating, general industry, and military applications. The control characteristics of these Inductro-Capacitron regulated rectifiers have a power factor of 100% and a maximum efficiency ratio of 96%. The units, with ratings up to 500 kw, can maintain constant voltage or current within $\pm 0.01\%$ regardless of load variations ranging from 0 to 100% or line variations of $\pm 10\%$. **Djeco Division of Djordjevic Engineering Co., 1933 N. Damen, Chicago 47, Ill.** *Circle 226 on the card.*

Circle 23 on the card ➤



QUALITY

CADWELD cable to lug electrical connections are superior to mechanical or soldered types.

Competitively priced, these quality connections are permanent and cannot loosen or corrode.

Simplified ordering—specify type connection and quantity only—equipment furnished automatically.

originators and developers of the copper thermit principle

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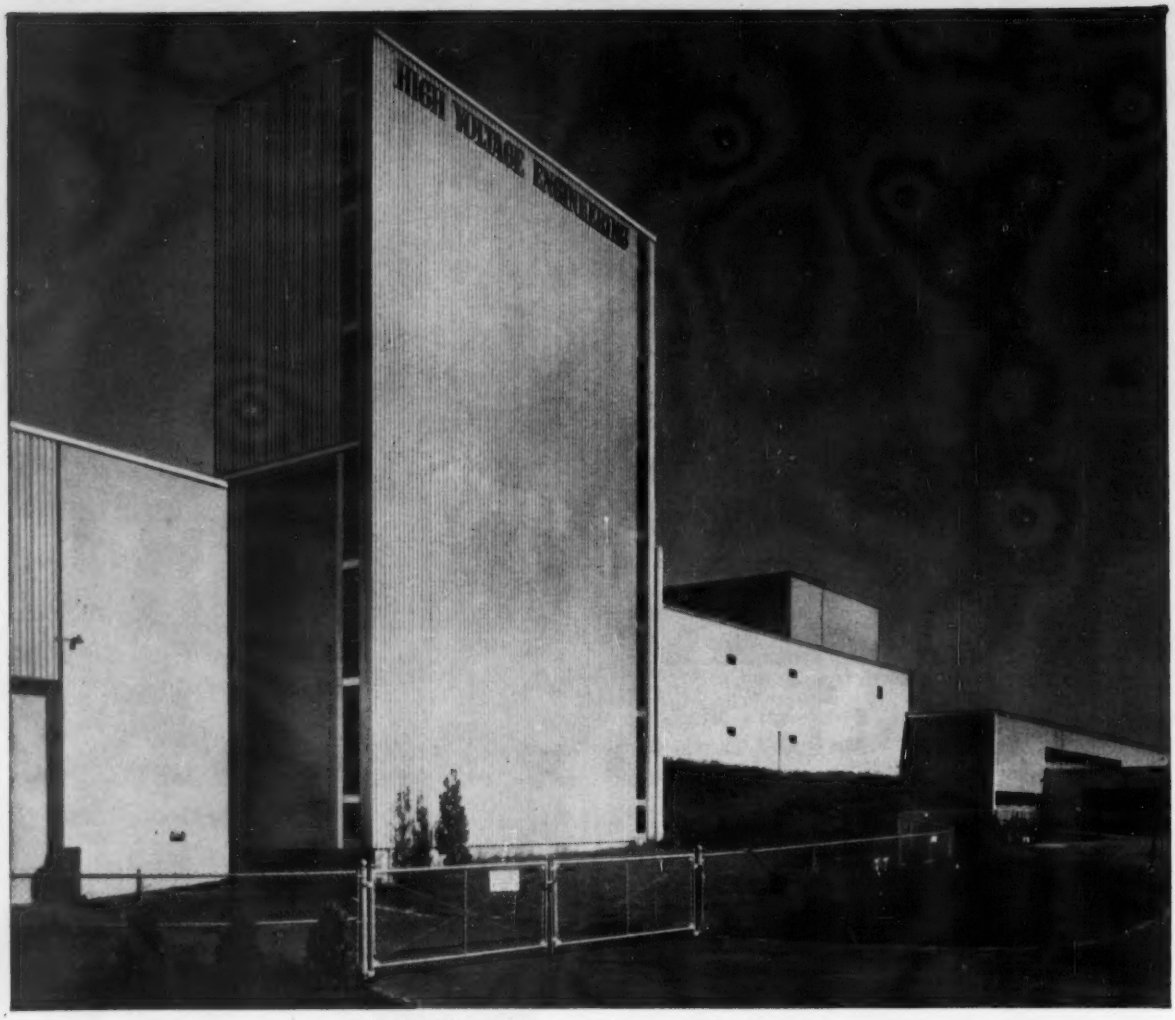
electrical connections

ERICO PRODUCTS, INC.

2070 E. 61st Place • Cleveland 3, Ohio



Partial View of the new plant on a 50-acre tract.

Architect: Carleton R. Richmond, Jr.; *Supervising engineers:* Stressenger, Adams, Maguire & Reidy; *General contractor:* Aberthaw Construction Co.; *Electrical contractor:* M. B. Foster Electric Co.

Another electrical manufacturer selected SORGEL dry-type transformers

for the operation of their plant

The HIGH VOLTAGE ENGINEERING COMPANY, in Burlington, Mass., the world's largest manufacturer of atom smashers, learned about the advantages of SORGEL dry-type transformers during an application with their product, which, on account of its nature, required the *best* transformers.

Being in a position to judge the quality of the transformers, they, like so many other electrical manufacturers, also selected SORGEL dry-type transformers for their own plant.

Complete line of dry-type transformers for every purpose

¼ Kva to 10,000 Kva — 120 to 15,000 volts

Quietest operation and high efficiency

●

Also special transformers, saturable reactors, and substations

Sales engineers in principal cities

SORGEL ELECTRIC CO., 846 West National Avenue, Milwaukee 4, Wisconsin

Over 40 years' experience in the development, manufacturing and application of transformers

For more information circle 24 on reader service card

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BUSINESS MACHINES

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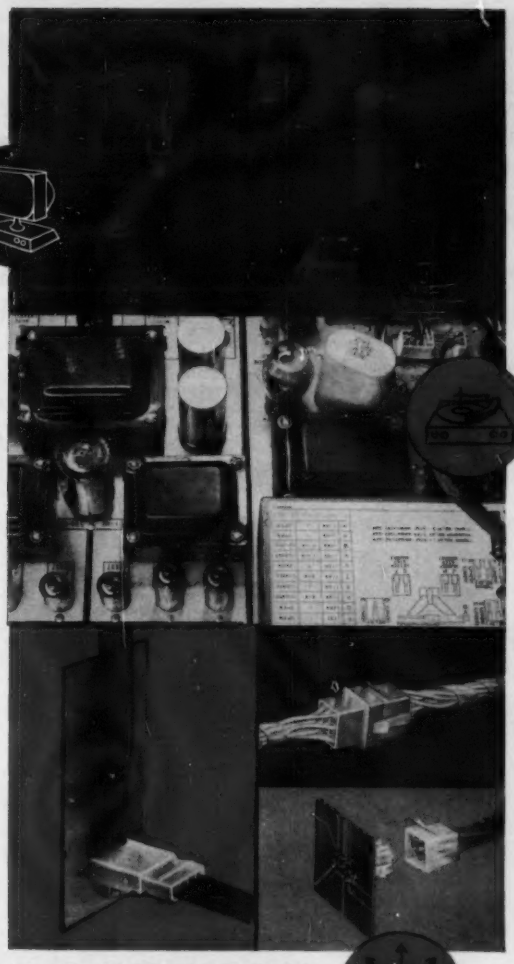

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EVERYWHERE

You won't have to look far to find an AMP-lok Multiple Circuit Connector. AMP-lok connectors have been used for the most diverse applications . . . for disconnecting multiple leads on—television deflection yokes, phonograph turn tables, electric ranges, washer and dryer control panels, and automotive instrument panels.

There are good reasons for the growing use of AMP-lok: It is available in 3, 4, 6, 9, or 12 circuit combinations. Attachment and assembly speeds run to thousands per hour. Uniform, reliable electrical characteristics are assured through AMP's compression crimp method. Automated techniques reduce total installed cost.

Versatility, reliability, economy and outstanding assembly speed—these factors explain why millions of AMP-lok connectors are being used everywhere. If you aren't using them for your circuit requirements, send today for more information.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

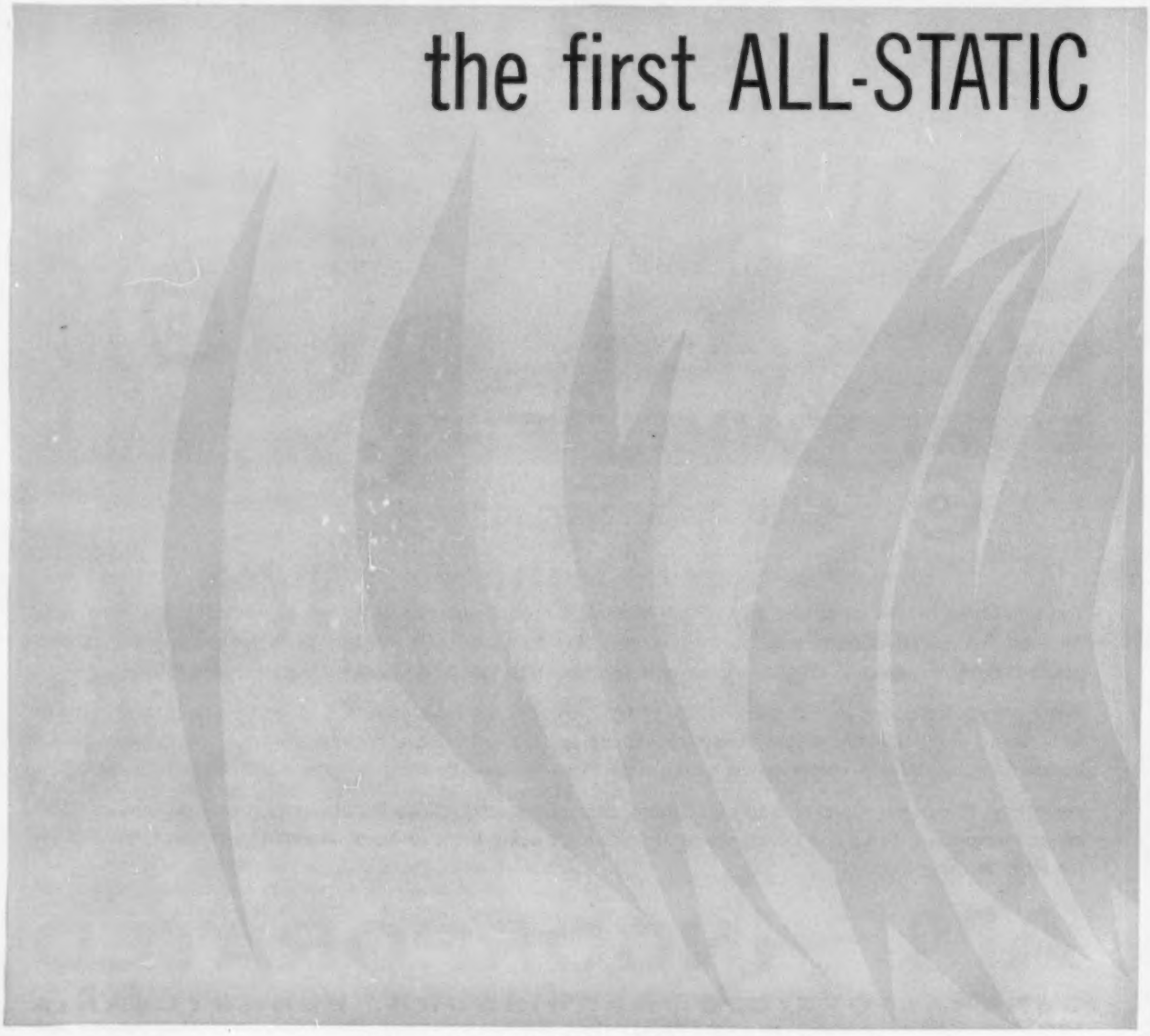
A-MP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Japan

For more information circle 25 on reader service card

The new Type SA represents a promising start toward realizing the potential advantages that abound in the use of semi-conductors. Based on 21 years of study and experience in static-relaying circuitry that started with our Type HCB relay in 1938, the SA holds promise for low maintenance, better sensitivity, lower op-

WESTINGHOUSE

the first ALL-STATIC



For more information circle 26 on reader service card

erating energy and more compact construction. Faster response will be limited only by the time required for integration (the thinking and command function).

Protective relaying took a long stride forward with the development of this new Westinghouse 3-phase relay for generator protection.

Call your Westinghouse sales engineer to get the story on our work in the field of statics and protective relaying. J-40527

YOU CAN BE SURE...IF IT'S **Westinghouse**

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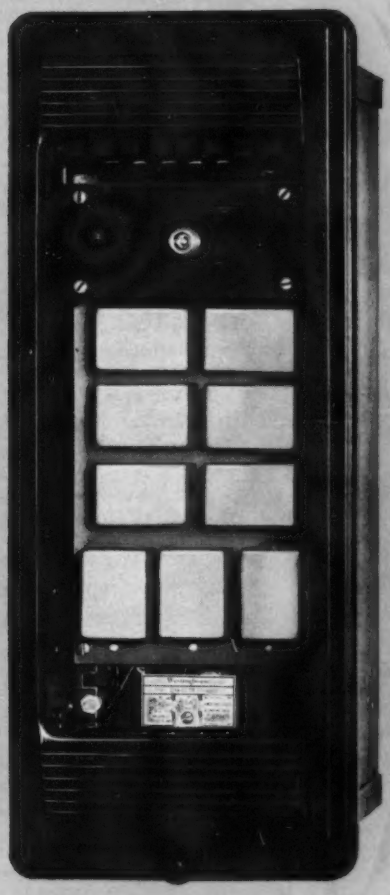
ANNOUNCES THE SA

differential generator relay



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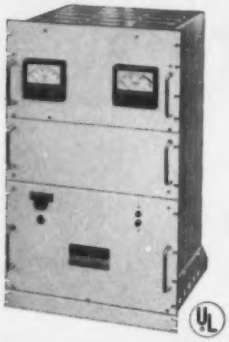
Precisely Regulated for Missile Testing and General Use



CHRISTIE

SILICON POWER SUPPLIES

available in 30 standardized and militarized models from 30 to 1500 amps... 6 to 135 volts. CHRISTIE'S QUALITY CONTROL is approved by the A.E.C., leading aircraft and missile manufacturers.

Write For Bulletin AC-58-A

CHRISTIE ELECTRIC CORP.

3410 W. 67th Street
Los Angeles 43, Calif.

Circle 27 on the card.

Industrial Notes...

Reynolds Metals Co. Detroit, Mich. . .

A distinctive new aluminum office building on Northwestern Highway at Northland Dr., Detroit 35, Mich., has been opened by the Reynolds Metals Co. at its

Great Lakes Region sales headquarters. It was designed by Minoru Yamasaki to dramatize the useful beauty of aluminum. Approximately 200,000 pounds of the light, strong metal were used. The greatest single use is in the gold anodized sun screen covering the second and third floors on all four sides. Into this unique application went 44,300 pounds of extruded tubing. In every instance, the use of aluminum was said to be governed by its usefulness, attractiveness, and economy both in original cost and in freedom from maintenance. Almost all that can be seen from the outside is either aluminum or glass. Inside, the uses of aluminum range from the furniture through office equipment to the diadem skylight arching 50 feet overhead and flooding the building with daylight.

Fischer & Porter Co. Hatboro, Pa. . .

The company's Los Angeles branch now offers complete calibration facilities for all major types of flow measuring devices. Any type of flowmeter can be calibrated. Tests simulating customers' operating conditions are accurate to ½ of 1%. For further information, write Fischer & Porter Co., 130 Orangethorpe Way, Anaheim, Calif.

U. S. Relay-Electronics Azusa, Calif. . .

In order to meet the growing space-age demand for completely reliable missile and aircraft components, U. S. Relay-Electronics, a Division of A-S-R Products Corp., has opened a new addition to its Azusa, Calif., plant designed to prevent dust or any other contaminant from entering hermetically sealed relay enclosures. In general, the 12,000 square-feet manufacturing area has been provided with an elaborate system of temperature, humidity, and dust controls. To further prevent dust particles from entering, air movement is always maintained outward from the assembly area by raising the internal air pressure substantially above the outside air pressure.

IBM White Plains, N. Y. . .

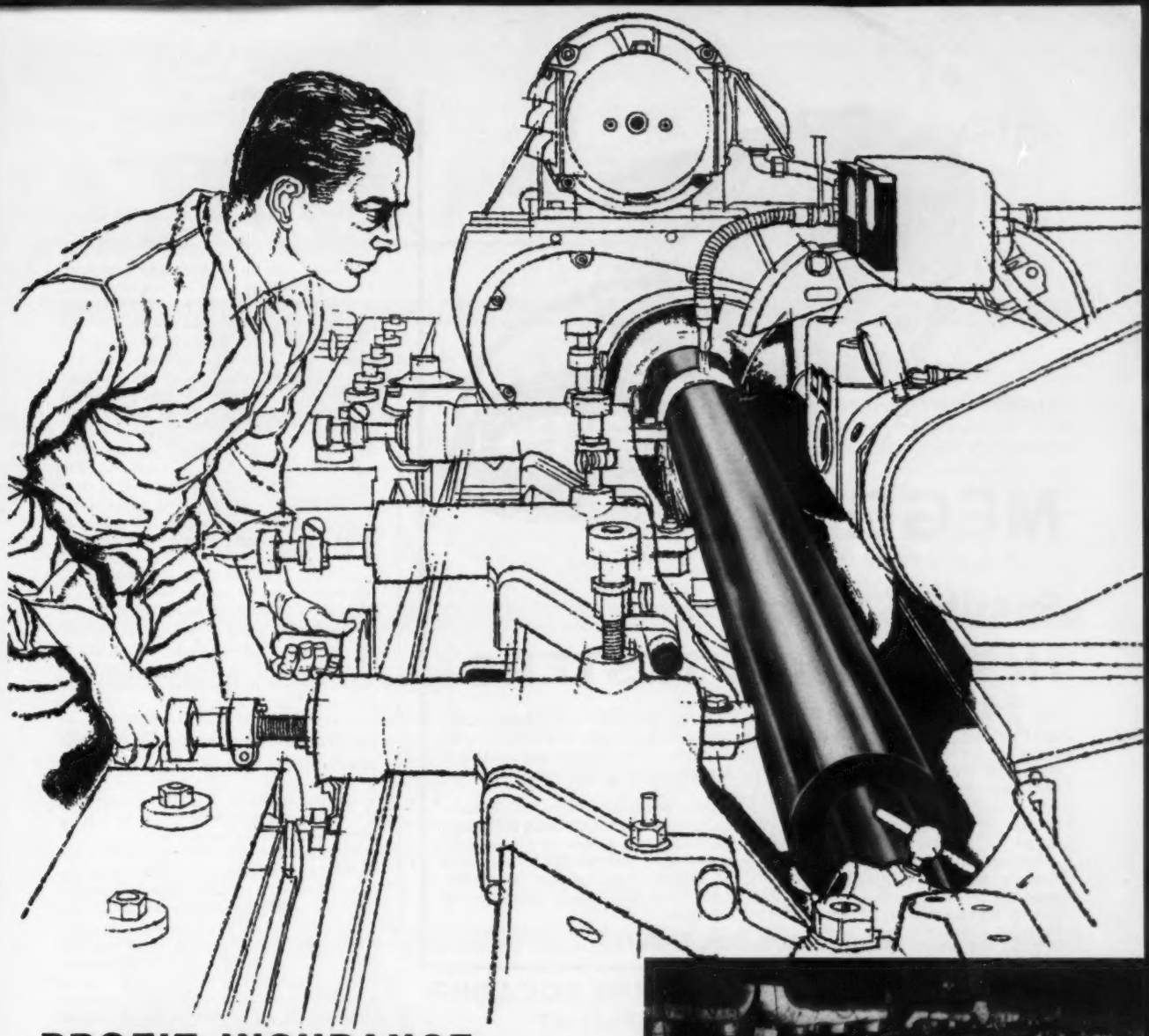
Computers by the hour soon will be available to businesses across the nation. International Business Machines Corp., 112 E. Post Rd., White Plains, N. Y., in a radical departure from its traditional leasing policy for data processing equipment, has announced that it would establish 25 to 30 Datacenters in major cities. These metropolitan Datacenters will each house an IBM *7070*, the most advanced transistorized commercial data processing system to be developed. They will be open to all businesses regardless of whether they have been IBM customers in the past. Datacenter customers may buy as little as 15 hours of computing time a month. IBM Datacenter users will supply their own programmers and operators. The rate for the *7070* system will be under $300 an hour.

Gulton Industries, Inc. Metuchen, N. J. . .

High-frequency sound waves are cutting the cleaning time of aircraft oil filters by 50% or more. The specially built ultrasonic cleaners, designed by Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J., are being used on filter components of the prop-jet engines on the

Lockheed Electra, now in service with many of the country's leading airlines. The 1-kw, 6-gallon units were built to specification for the Allison Division of General Motors whose 3,750-hp engines power the huge airliners. The use of sonic energy for less than 10 minutes accomplishes what previously required 20 minutes of hand scrubbing with costly solvents.

(Continued on page 38A)



PROFIT INSURANCE with J&L Stainless Steel Bars

Your machining costs on stainless steel bars are part of your investment for profit. Add your costs for tooling, handling and polishing, and you multiply your investment, often many times over.

Scrapping a single bar wipes out that investment—and with it most of your profit on a large volume of finished goods.

Every step taken to reduce rejects helps insure profits! The biggest step you can take in that direction is to specify J&L **Consistent** Quality on all orders for stainless steel.

J&L leads the industry in melt shop standards for stainless steel —the point where quality starts, **and your profit insurance begins.**

Careful attention to every production detail is the key to J&L quality

J&L STAINLESS
SHEET • STRIP • BAR • WIRE

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OF

MEGGER

(Reg. U. S. Patent Office)

Rectifier-Operated

INSULATION TESTERS

For repetitive insulation resistance tests on a production basis . . . and for time-resistance tests . . . nothing equals the Meg Type Rectifier-Operated Insulation Tester for convenience and reliability. The plug-in rectifier source of power permits the instrument to be used without hand cranking. A constant-voltage feature reduces pointer fluctuations which may occur when testing equipment having appreciable capacitance, such as larger generators and long cables. Standard units are available for 500 or 1000 volts d-c test potential and for ranges up to 2000 megohms.

Other Megger Insulation Testers include hand-crank models and Dual-Operated sets. The latter are versatile instruments with rectifier for repetitive or time-testing that can be disconnected for hand-crank operation in the field.

Write for BULLETIN 21-46-EE

BIDDLE IMPULSE CABLE FAULT LOCATING EQUIPMENT

. . . for locating cable faults by impulse tracer method . . . for D-C proof testing. Applicable to aerial and buried cable as well as lead-covered cable in ducts. Transmitter can be connected to 115 V, 60 cps supply.

MODEL 3-2—Output voltage up to 25 kv. Discharge capacitance 1.65 muf. For use on cable up to 15 kv rating.

MODEL 4-2—Output voltage up to 15 kv. Discharge capacitance 2 muf. For use on cable up to 5 kv rating.

MODEL 5-2—Output voltage up to 5 kv. Discharge capacitance 16 muf. For use on cable up to 1 kv rating.

Write for BULLETIN 65-EE

JAMES G. BIDDLE CO.

• ELECTRICAL TESTING INSTRUMENTS
• SPEED MEASURING INSTRUMENTS
• LABORATORY & SCIENTIFIC EQUIPMENT

1316 ARCH STREET
PHILADELPHIA 7, PA.

Circle 29 on the card.

Industrial Notes

(Continued from page 36A)

Baldwin-Lima-Hamilton Corp. Philadelphia, Pa. . .

Whole I-beams, as long as 40 feet and weighing as much as 2,500 pounds, are being weighed immediately after rolling at a large eastern Pennsylvania steel mill. The weighing is done on an electronic device, the *SR-4* electronic weighing system. With this electronic system, instructions can be flashed instantly to the roller, should the beams be outside the 2% tolerances allowed. Subsequent rollings can be adjusted to fall within prescribed tolerances. A beam is weighed at the front of the hot bed before it is moved to the rear for cooling. With no moving parts and extreme simplicity of operation, the *SR-4* load cell is ideally suited for such a job as this I-beam weighing application. Because *SR-4* load cells are self-enclosed, oil and dirt cannot damage the cell interiors. Likewise there are no mechanical parts to be damaged, since electrical cables transmit the weight from the load cells to the dial. There are no knife edges, no bearings, no hydraulic systems to maintain, nor any pivot points to lubricate. Baldwin-Lima-Hamilton Corp., Philadelphia National Bank Bldg., Philadelphia, Pa.

The Narde Ultrasonics Corp. Westbury, L. I., N. Y. . .

The SonBlaster *M-1* Ultrasonic Missile Cleaner, a self-propelled 24-foot long ultrasonic cleaning tank powered by a 30-kw ultrasonic frequency generator, is designed for missile launching sites in accordance with ground support concepts; the huge mobile cleaning system is capable of accommodating most operational solid and liquid fuel, missile assemblies, and engines. The SonBlaster *M-2* Ultrasonic Liquid Fuel Pipe Line Cleaner, a system using high frequency vibrations to prevent build-up of sediment and contaminants on the inside walls of fuel lines, includes a self-propelled ultrasonic generator and a series of quick coupling transducers which, when attached to the pipe line, introduce high-frequency sound waves throughout the structure. These inaudible sound waves prevent foreign matter from adhering to the walls.

H. K. Porter Co., Inc. Riverside, N. J. . .

A plastic spool now in use at Alloy Metal Wire Works, Riverside-Alloy Metal Division, H. K. Porter Co., Inc., Riverside, N. J., has cut the customer deposit required by 73%. Easier to handle than metal spools, the new put-up is used for weaving wire. No equipment changes are necessary to handle the plastic spools. They are used as a 5-pound put-up on Almet stainless steel, Monel, Nickel, Inconel, and many other alloys. Primarily for weaving wire, the spools have also been used as a put-up for other wire requiring a soft temper.

(Continued on page 46A)

3 STOCK RELAYS for Day-In Day-Out Reliability

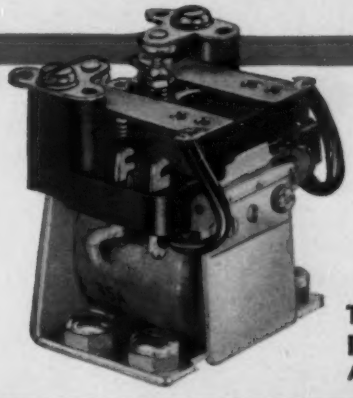
Type **DO** AC-DC

For Severe Shock and Vibration

A rugged relay, particularly adaptable to aircraft and mobile applications. Design of molded parts around contact arms prevents mechanical injury. Available in twenty-three 3-pole and 4-pole types. *Coil Wattage:* 3.00 watts, DC operation; 6.00 watts, 60 cycle AC. Maximum temperature rise 45° C, DC; 75° C, AC. *Coil Operating Voltages:* from 6 to 230 VAC (60 cycles) and 6 to 220 VDC. *Contacts:* Fine silver. Rated for 115 VAC or 32 VDC, non-inductive load. *Weight:* 3-pole, approximately 5 ounces; 4-pole, 6 ounces.

Compact and Lightweight

A general-purpose relay of wide application. Handles loads usually demanded of much larger relays. Meets rigorous aircraft relay standards. Twenty single-and double-pole types. *Coil Wattage:* 2.5 watts, DC; 3 watts, 60 cycle AC. Maximum temperature 45° C, DC; 65° C, AC. *Coil Operating Voltages:* from 6 to 230 VAC (60 cycles) and 6 to 220 VDC. *Contacts:* Fine silver is standard. Rated for 115 VAC or 32 VDC, non-inductive load. *Weight:* Approximately 4 ounces.



Type **DOS** AC-DC

Type **DOSY** DC

Twin Coils for Extra Sensitivity

Similar in construction to Model DOS. The DOSY relay is adaptable to a wide range of electronic applications such as plate circuit controls or as overload or underload controls in DC circuits to signal attainment of predetermined current levels. Four single- and double-pole types. *Coil Wattage:* 1.00 watt, with maximum temperature rise of 45° C. *Contacts:* Fine silver. Rated for 115 VAC or 32 VDC, non-inductive load. *Weight:* Approximately 4½ ounces.

Write for Stock Catalog 30

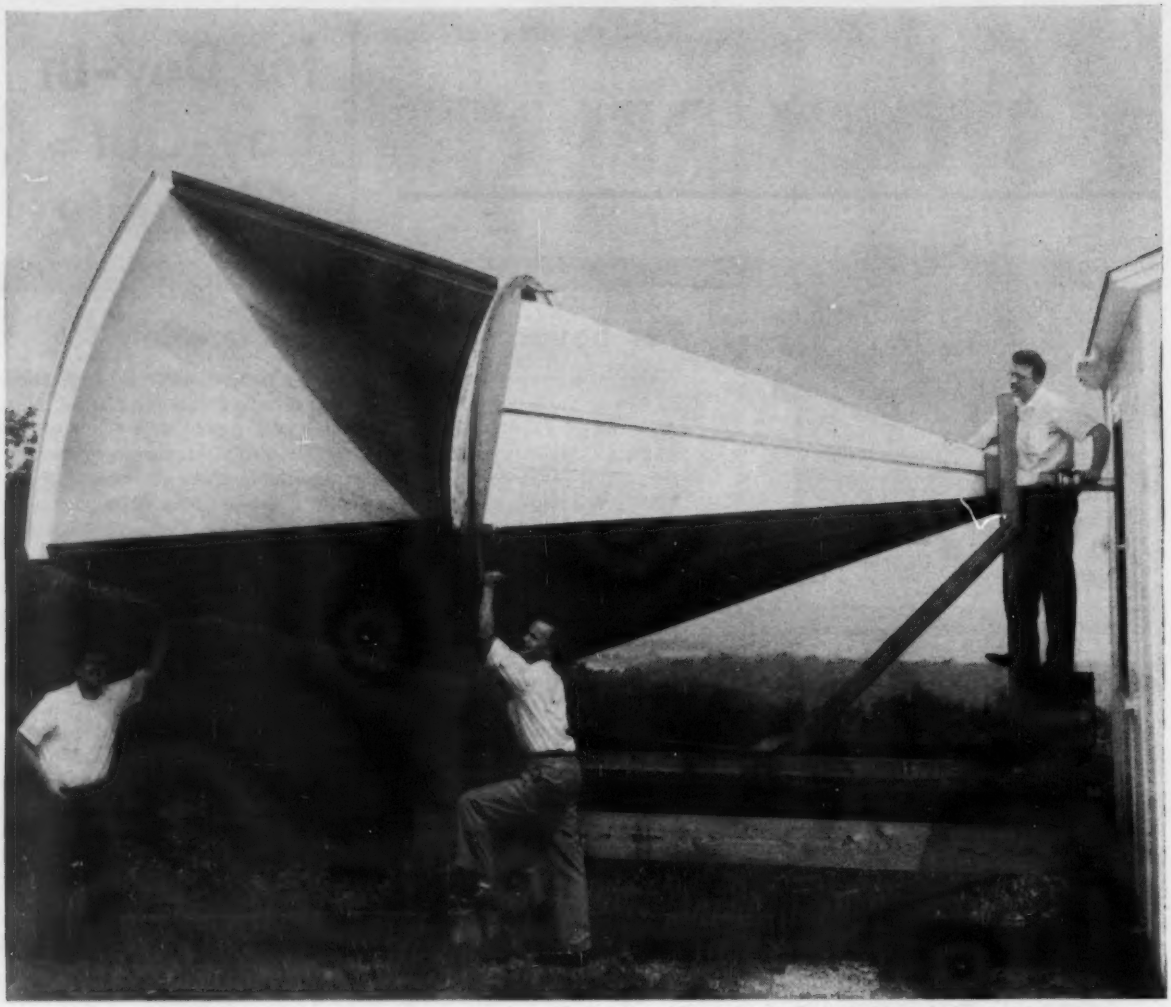
Also other quality relays of many types

RHEOSTATS • RESISTORS • RELAYS
TAP SWITCHES • R.F. CHOKES
VARIABLE TRANSFORMERS
TANTALUM CAPACITORS
GERMANIUM DIODES

OHMITE® QUALITY Components

OHMITE MANUFACTURING COMPANY
3614 Howard Street, Skokie, Illinois

For more information circle 30 on reader service card



At Bell Laboratories, Holmdel, N. J., a horn reflector antenna is beamed skyward by scientists Edward Ohm, David Hogg and Robert DeGrasse. The maser amplifier, which employs a ruby cooled in liquid helium, is inside building at right. Over-all "noise" temperature of antenna, amplifier and sky is only 18°K at 5600 megacycles.

ANOTHER STEP TOWARD SPACE COMMUNICATIONS

The above antenna is part of a new ultra-sensitive radio receiving system under development at Bell Telephone Laboratories. It has extraordinary directivity. Beamed skyward, it ignores radio "noise" from the earth, yet picks up extremely weak signals from outer space.

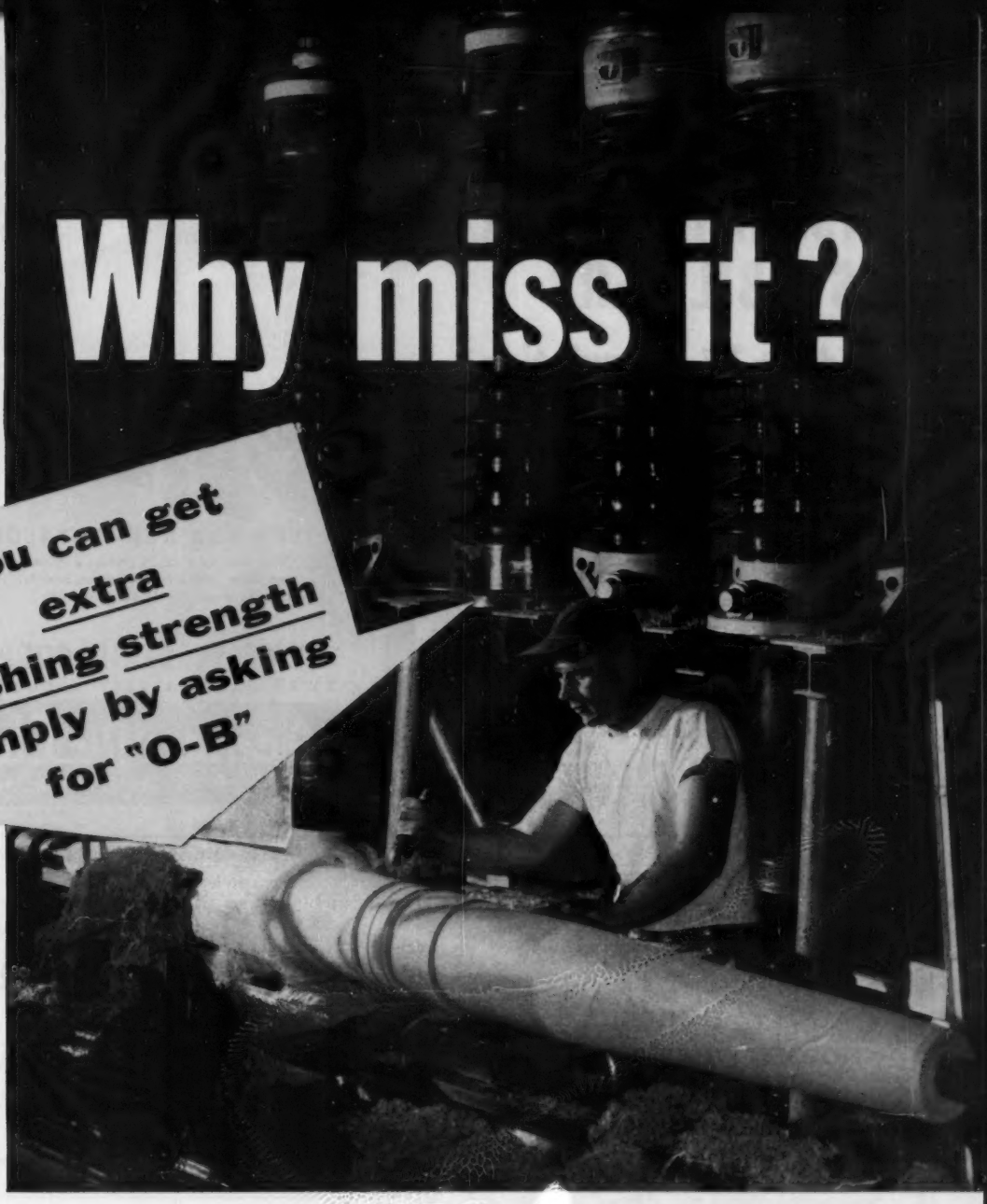
The signals are amplified by the latest Bell Laboratories "maser" amplifier. The maser principle was first demonstrated, using gas, by Prof. C. H. Townes and his collaborators at Columbia University. Bell Laboratories scientists applied it to the solid state guided by a theoretical proposal of Prof. N. Bloembergen of Harvard University. Their latest traveling wave maser amplifier employs a ruby mounted in a waveguide. The ruby is excited to store energy. As signals pass through, they absorb this energy and are thus amplified. The device uniquely combines the characteristics needed for practical space communication: extremely low inherent noise and the ability to amplify a broad frequency band.

At present the receiving system is being used to pick up and measure minute radio noise generated by the atmosphere. It also foreshadows important advances in long distance communications. For example, it could extend the range of space-probe telemetering systems, could help make possible the transatlantic transmission of telephone and TV signals by bouncing them off balloon satellites—and has numerous applications in radio astronomy and radar.

This pioneer development in radio reception is one more example of the role Bell Laboratories plays in the pursuit of better communications technology.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT



Why miss it?

You can get extra bushing strength simply by asking for "O-B"

The industry's most modern methods of producing a bushing core impart to O-B's design a unique degree of hardness and strength. These desirable qualities are exploited to produce the strongest bushing in nearly 50 years of manufacturing experience.

Many points of firm contact are established between the core and ground sleeve structure, thereby augmenting over-all rigidity. This is distinctly an O-B construction principle.

Higher physical strength assures safer shipment. It reduces possible damage by careless handling. And then - - in service - - it gives a lifetime of better support for circuit breaker parts, and higher resistance to other strains inherent in bushing application.

Your new apparatus can have O-B bushing protection so easily that you can't afford to miss it. Simply express your choice of bushings when ordering transformers and circuit breakers.

OHIO BRASS COMPANY, MANSFIELD, OHIO

Canadian Ohio Brass Co., Ltd., Niagara Falls, Ont.

Ohio Brass HOLAN

PORCELAIN INSULATORS · LINE HARDWARE · CAPACITORS · LIGHTNING ARRESTERS
BUSHINGS · HOLAN TRUCK-MOUNTED POWER DEVICES AND BODIES · BRONZE VALVES

4927-H

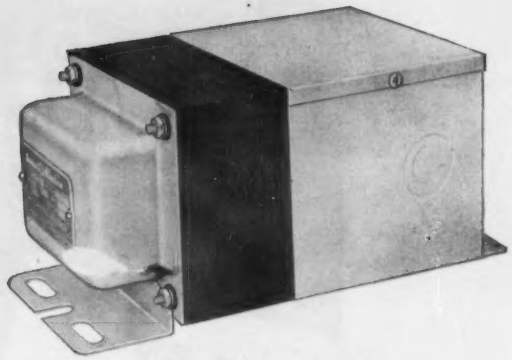
Acme ACME Electric

CONSTANT VOLTAGE STABILIZERS

Provide ±1% Regulation, Overload Protection

This new series of Acme Electric constant voltage stabilizers include all the features engineers requested in custom made units. Designed to stabilize a voltage which may vary over a range as much as 30%. Stabilization response is practically instantaneous; inductive surges or other causes of fluctuation are corrected within 1/30 of a second.

Under overload or short circuit condition, output voltage automatically drops to zero thus limiting the current and providing full protection.



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TRANSFORMERS

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Simply stated, engineers apply the sciences to give people use of nature's materials, forces.

Scientists make it known. Engineers make it useful.

Scientists split the atom; engineers design and build the atomic power plants.

All science known would benefit nobody if not applied by engineers to manufacturing, construction, mining, agriculture or the generation of power.

These are the great engineered industries—all based on scientific knowledge.

Engineers plan, design, produce, maintain and *operate.* To repeat: *Scientists make it known. Engineers make it useful.*

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SOLID! Section of Roebel bar for 22,000 Volt, 76,000 KVA turbogenerator stator.

The outstanding insulation for high voltage coils

NECCOBOND...solid insulation bonded to the copper provides longer life, greater strength and stability

In NECCOBOND, National has developed a complete insulation system, using mica, glass and a special impregnant. Its particular advantages for high voltage coils are:

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NECCOBOND is based on time-proven insulating materials – mica and glass. These are welded by a special impregnant into a tenaciously bonded, resilient, voidless insulation wall. A unique method of fabrication assures homogeneous insulation.

When replacing high voltage coils, investigate the long term savings with NECCOBOND. You'll find our advice impartial—we offer all types of insulation.

For more information, call National's Columbus Plant . . . HUdson 8-1151. Or call your nearby National field engineer.

McGRAW EDISON

National Electric Coil

DIVISION OF McGRAW-EDISON COMPANY
COLUMBUS 16, OHIO

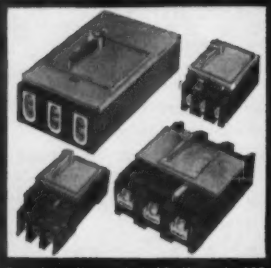
ELECTRICAL ENGINEERS • MANUFACTURERS OF ELECTRICAL COILS, INSULATION, LIFTING MAGNETS
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

For more information circle 33 on reader service card

Another Engineering Achievement

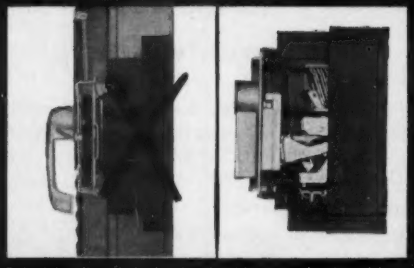
now Federal Pacific introduces the ROTARY HANDLE CIRCUIT BREAKER!

it's new...



Complete line rated 15 through 800 amperes in four breaker frame sizes: EF 100a, F 225a, J 400a and M 800a

it's safe...



Rotary handle eliminates the trouble zone of external handle mechanisms, always indicates true position of breaker mechanism, provides greater dependability and safety.

it locks!

Unique locking ring accommodates 3 padlocks. Can also be locked with a key.

FIRST REAL CHANGE IN AB BREAKERS SINCE 1927...Obsoletes flip-handle circuit breakers. Federal Pacific's new integral handle eliminates excess, trouble-making linkage...Handle position always indicates breaker position...built big and rugged for industrial use in switchboards, control centers, control panels, panelboards, and individual enclosures—you can see this man-sized handle from a distance...Uses easy to operate rotary action...Unique locking feature for safety—Get the details of this stride forward in AB breaker design now. Write for Bulletin #1425, Federal Pacific Electric Company, General Offices: Department 328, Newark 1, New Jersey.

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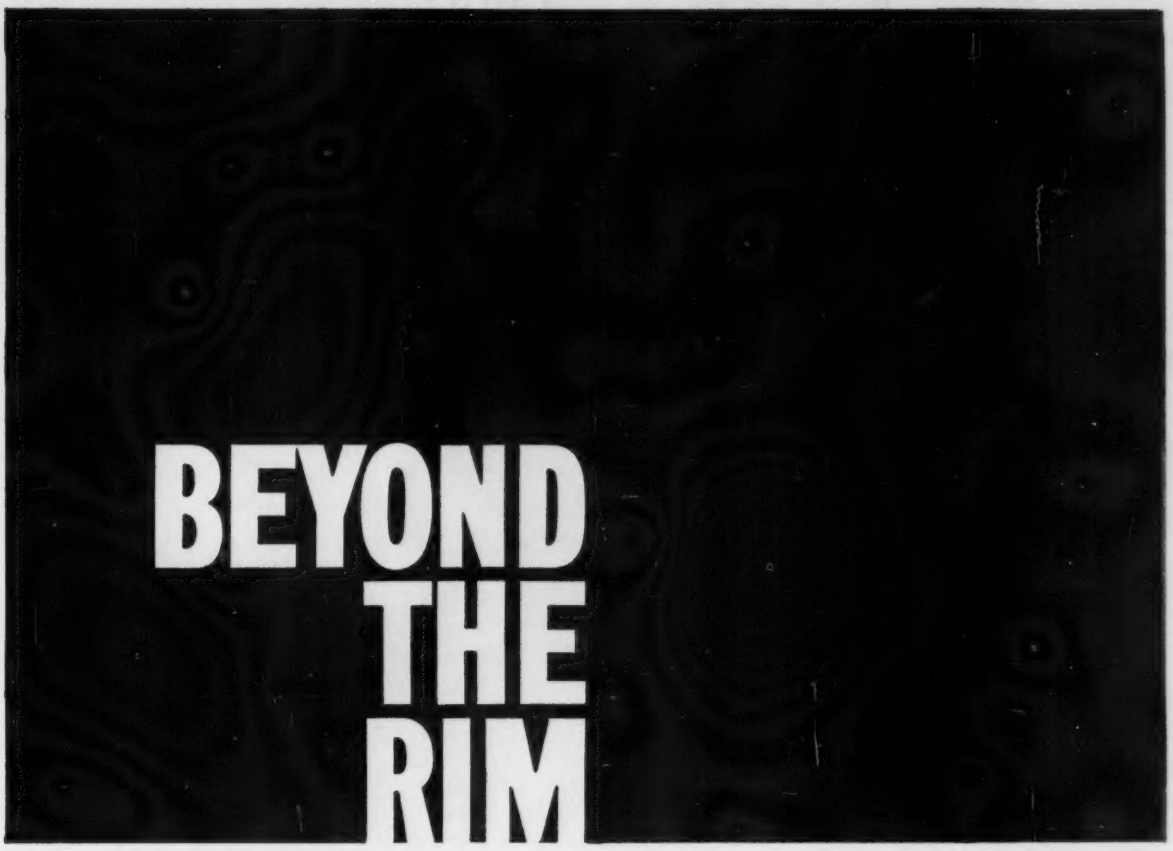
The Best in Electrical Distribution and Control Equipment.



Today mankind is embarked on the most exciting voyage of discovery since Columbus sailed beyond the rim of the known world.

In a physical sense, it is a voyage that ranges from investigation of the infinitesimal components of matter to exploration of the vastness of the cosmos.

But at Sandia Laboratory it is a voyage of the mind — a voyage beyond the rim of our present comprehensions, to unlimited destinations.

At our laboratories in Albuquerque, N. M. and Livermore, California, we perform research and development pertaining to nuclear weapons and certain allied non-military projects for the Atomic Energy Commission. We need men with the knowledge, the experience, and the desire to venture beyond the rim in many fields of science and engineering. At present, we have challenging opportunities in these specific fields:

PHYSICS and MATHEMATICS — Scientists at PhD level for both fundamental and applied research, at Albuquerque and Livermore.

EXPLOSIVES CHEMISTRY — Chemists or chemical engineers with advanced degrees and extensive experience in this field, at Albuquerque.

STATISTICS — Experienced statisticians with MS or PhD degrees and interest in statistical methods and quality control, particularly in statistical design of experiments. Required at Albuquerque only.

QUALITY CONTROL — Industrial, mechanical, and electrical engineers with experience in quality control methods development and training assignments, at Albuquerque only.

STRESS ANALYSIS — Experienced mechanical or aeronautical engineers, preferably with advanced degrees, at both Albuquerque and Livermore.

HUMAN ENGINEERING — Experienced personnel with advanced degrees in psychology plus engineering degrees, at Albuquerque only.

ELECTRICAL or MECHANICAL DESIGN and DEVELOPMENT ENGINEERING — Experienced personnel with BS or MS degrees, at both Albuquerque and Livermore.

AERODYNAMICS — Research and development in the fields of space and high-altitude rockets; hypersonic research; magnetic theory; supersonic parachutes; nuclear weapon aerodynamics; and high velocity research apparatus design, at Albuquerque.

MANUFACTURING DEVELOPMENT ENGINEERS — Electrical, Mechanical or Industrial degrees — to be in charge on a nationwide basis of products during the manufacturing phase, at Albuquerque only.

COMPUTER ENGINEERS — Engineers at the MS or PhD level with three to five years experience in advanced computer systems, digital techniques or control system design, at Albuquerque only.

Sandia Laboratory offers many advanced and specialized facilities to further work of its scientists and engineers. Liberal employee benefits, including generous vacations and holidays, insurance and retirement plans, educational aid program, add to Sandia's attractiveness as a place to work. Albuquerque, a city of over 225,000 with a mild, dry climate and friendly Southwestern atmosphere, is a delightful place in which to live. Livermore, located in the San Francisco Bay area, offers suburban advantages close to metropolitan San Francisco.

IF YOU ARE INTERESTED in a career at Sandia, our illustrated brochure will tell you more about the opportunities we offer to advanced scientists and engineers. Write to Employment Section 551E at either Albuquerque, N. M., or Livermore, California.

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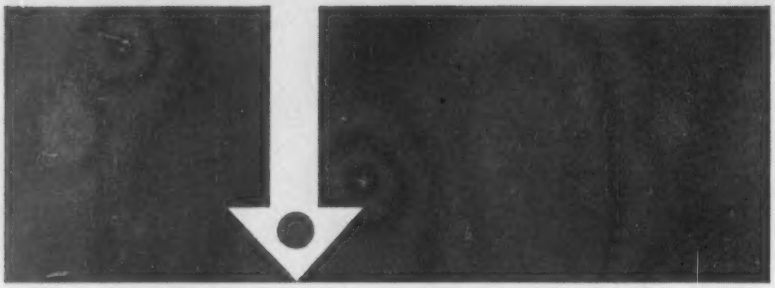

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1. Photoelasticity is being studied to determine strain propagation as a function of time in solids. This work is designed to clarify laws governing impulse strain waves, as well as to determine dynamic stresses that exist in impact and other phenomena.
2. Fundamentals of the magnetic properties of materials are under study. The immediate interests are spin-wave investigations, particularly those relating to the switching times of remagnetization and spin-wave propagation in polycrystalline materials.
3. Optical techniques, with organic and inorganic thin films, are being used to examine the properties of absorption phenomena in surfaces and substrates.

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Industrial Notes

(Continued from page 38A)

Federal Sign and Signal Corp. Blue Island, Ill.

Federal Sign and Signal Corp., one of the nation's oldest and largest producers of vehicle and industrial emergency lights, sirens, and horns, has moved its general offices and Chicago production operations from Chicago's South Side into a modern 1-story plant at 136th St. and Western Ave., Blue Island, Ill. The company has streamlined its production, testing, and research and development operations in the new location, and will be able to expand its services substantially to both business and communities.

Radio Corp. of America New York, N. Y. . .

Commercial radiotelegraph service has been extended to passengers aboard flights through an agreement between El Al Israel Airlines and RCA Communications, Inc., 66 Broad St., New York, N. Y. As a result, passengers aboard El Al airliners can now send and receive personal and business radiograms via RCA in the same manner as passengers aboard ocean liners. Hotel and car rental reservations also can be made via the new service.

San Fernando Electric Mfg. Co. San Fernando, Calif. . .

Miniature electric capacitors for aircraft, missiles, and radar units made by San Fernando Electric Manufacturing Co., 1509 First St., San Fernando, Calif., utilize the unique properties of silicone oils for insulation and cooling purposes. "Union Carbide" *L-45* silicone oil, electrical grade, is used by San Fernando because of its ability to withstand extreme temperatures, ranging from —55 to 125 C, and its high degree of reliability. These capacitors far exceed the characteristic K requirement of military specifications. West-Cap is the registered trade-mark for the capacitors and filters.

Firestone Akron, Ohio . . .

An unusual process for the moisture proofing of both natural and man-made fibers may find application in the manufacture of a substantial proportion of the paper produced in this country and may have important applications in the tire, printed electric circuit board, electrical insulation and molded fiberboard fields. The process employs a series of unique steps involving treatment of the fibers before impregnating them with various resins. These operations are performed by equipment designed and originated for these purposes. The Firestone Tire and Rubber Co., 1200 Firestone Pkwy., Akron 17, Ohio.

(Continued on page 48A)

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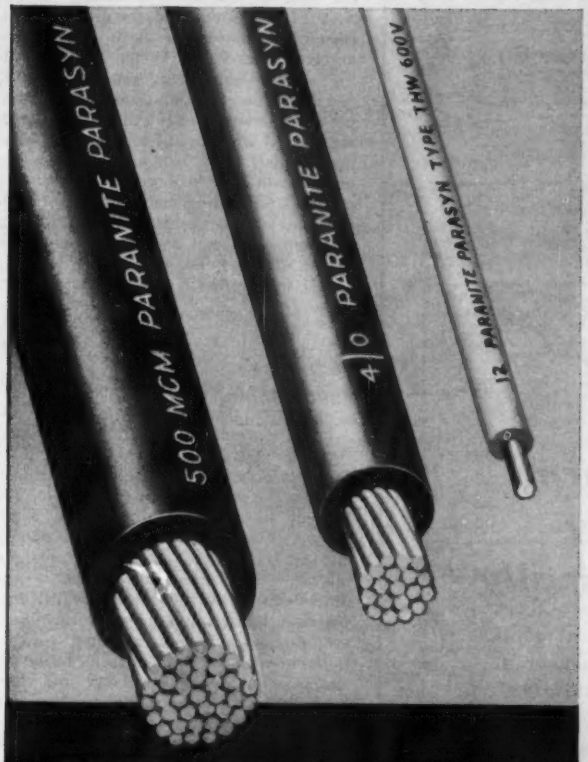

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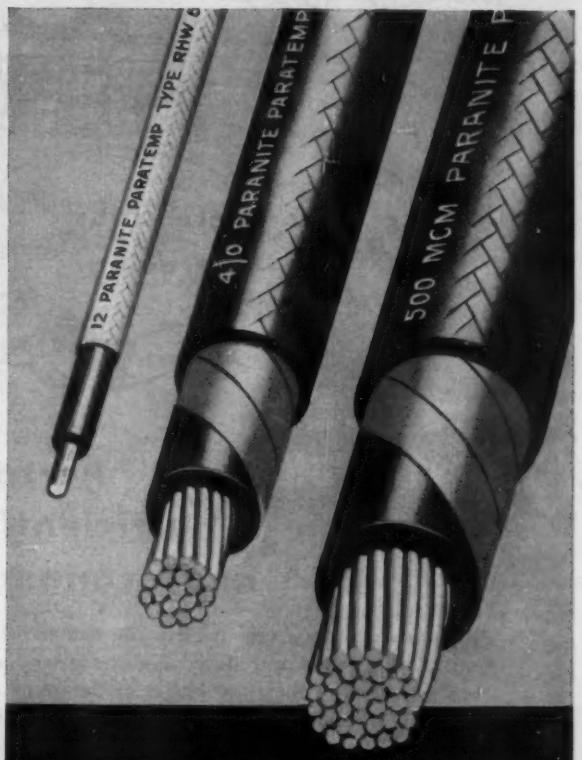

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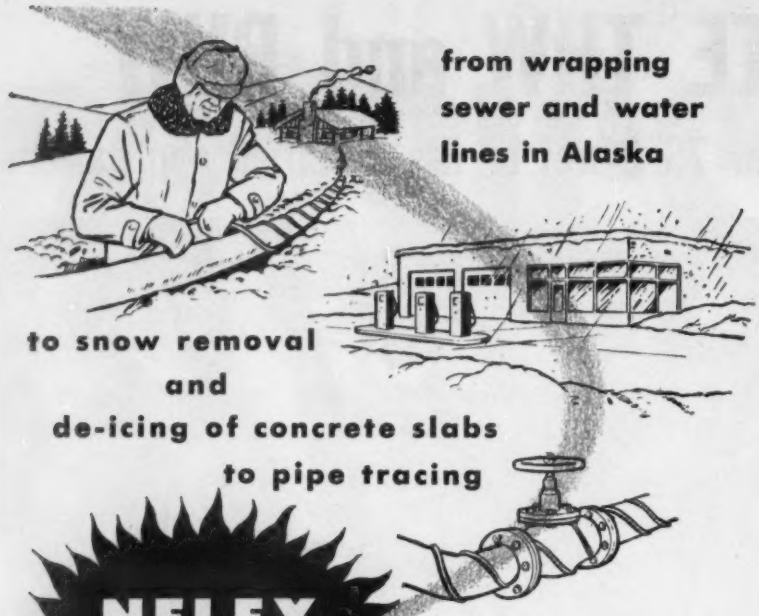

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Write for Bulletin 1603. This brochure gives you complete information and performance characteristics of Nelex Heater Units.

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Industrial Notes

(*Continued from page 46A*)

Leeds & Northrup North Wales, Pa. . .

Automation, which is still in its infancy, will reach maturity when machines can talk to machines, according to Dr. A. V. Astin, director of the National Bureau of Standards. Dr. Astin, who spoke at ceremonies in N. Wales, Pa., dedicating a new research center of Leeds & Northrup Co., said that some fairly simple instruments already at hand are speeding the day when even marketing decisions may be part of an automated production distribution process. Leeds & Northrup, a pioneer and leading manufacturer of high precision electronic instruments and control apparatus will concentrate its activities in the new laboratory which covers 65,000 square feet.

Philco Corp. Philadelphia, Pa. . .

An extremely accurate radar target simulator has been developed by Philco Corporation's Government and Industrial Division to meet the specifications of the Federal Electric Corp., Paramus, N. J. This simulator, designed for the training and practice of radar operators, does not interfere with normal operation of the radar equipment. Thus, both real and synthetic radar returns may be displayed simultaneously. When operated in conjunction with an early warning radar system, it generates azimuth, range, and video information for separate targets which will maneuver realistically under the precise control of the operator. The accelerated time-scale gating circuit has the advantage of generating a realistic constant range arc in simulation of an echo blip, while still responding to the antenna sweep at the exact radar pulse repetition frequency. Completely housed in a console designed to enable convenient control of the three targets by a single operator, it operates directly from a single-phase 115-volt 60-cycle power source and requires only three connections to the radar.

Raytheon Co. Waltham, Mass. . .

A device that simulates submarines electronically is being delivered to the U. S. Navy to speed training in antisubmarine warfare. Produced by Raytheon Co., Waltham 54, Mass., the new sonar trainer makes training possible at sea without scheduling other submarines to act as targets. Its synthetic target, indistinguishable from real "echoes," may be cleared from sonar scopes immediately should a second target appear. The trainer frees submarines for other duties, but its electronic brain fakes all real maneuvers including dives, varying courses, speed changes, and torpedo attacks.

Spaulding FIBRE FACTS FOR ENGINEERS NUMBER 2

THE USES OF VULCANIZED FIBRE'S INHERENT TOUGHNESS

by Earl A. Russell, Chief Engineer, Spaulding Fibre Company, Inc.

The toughness of Vulcanized Fibre often contributes uniquely to meeting crucial requirements of an application as well as to making possible low cost fabrication. For example a vulcanized fibre kickback plate in a bowling alley makes effective use of its built-in toughness while in an automobile starter switch the toughness of fibre permits swaging a supporting bushing to fit the switch case.

What die casting does in reducing the cost of odd shaped parts in metals, swaging does with vulcanized fibre. In addition to being tough enough to readily withstand punching operations, it is also sufficiently plastic to permit swaging to shape. In this particular swaging operation the fibre is compressed in some areas and flowed into raised areas to form a shank fitting into the hole and a shoulder fitting the contour of the starter switch case (Fig. 1).

In the assembly the sturdy switch contacts are economically mounted and fully insulated with vulcanized fibre, taking advantage of the toughness of the fibre parts to provide adequate support against the impact of entering switch contacts.

It may be noted further that combined with the toughness to withstand punching and the plasticity to permit swaging into low cost parts, vulcanized fibre provides the required electrical insulation.

In the bowling alley application (Fig. 2) wood could not take the beating from the pounding blows of the pins as they smash against the partitions that separate the alleys. For protection of the wooden partition, the toughness of vulcanized fibre is required to withstand the repeated blows from the pins. At the same time the fibre must be sufficiently plastic to avoid damaging the pins yet resilient enough to provide acceptable rebound for desirable pin action.

Fibre performs these unusual functions through years of service at surprisingly low cost.

In railroad track insulation, athletic protective parts, gaskets for high pressure systems, switch parts, electric motor parts and formed parts for many applications, the toughness of fibre combines with other important properties to provide a simple part which performs two or more functions with good results and low cost.

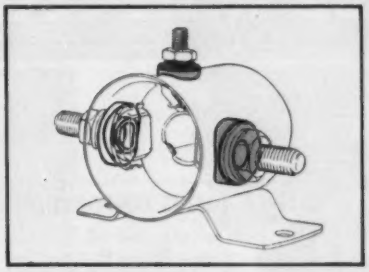

FIGURE 1. A complex shape difficult to machine by ordinary methods, this vulcanized fibre bushing is swaged and punched in one operation to produce a low cost part to meet strict requirements of toughness. Supporting heavy duty contacts under repeated shock loads, the bushing also insulates the contacts against the surrounding case.

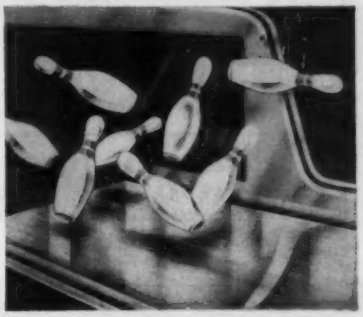

FIGURE 2. Tough vulcanized fibre kickback plate absorbs the impact of the flying pin without damage to the pin or the partition. The rebound action, so necessary to top scores, is possible because of the resiliency of the fibre.

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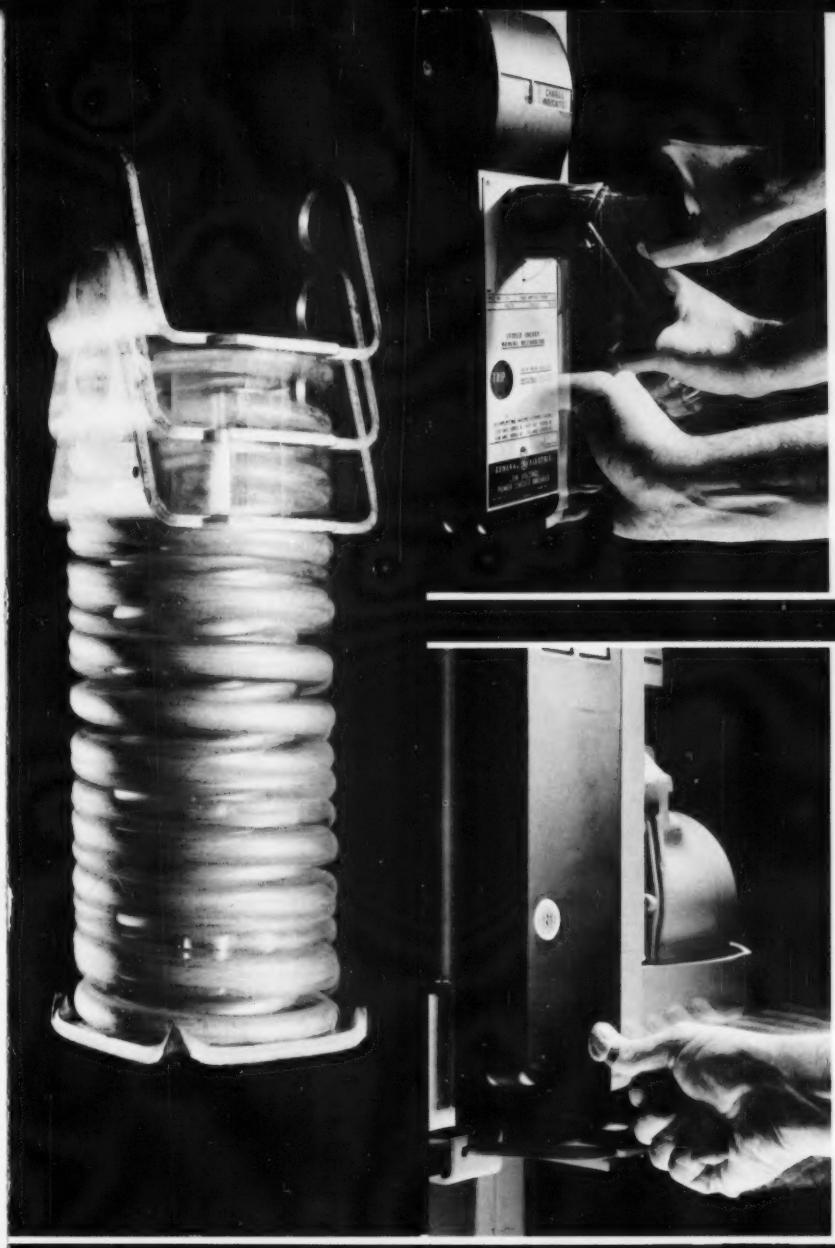

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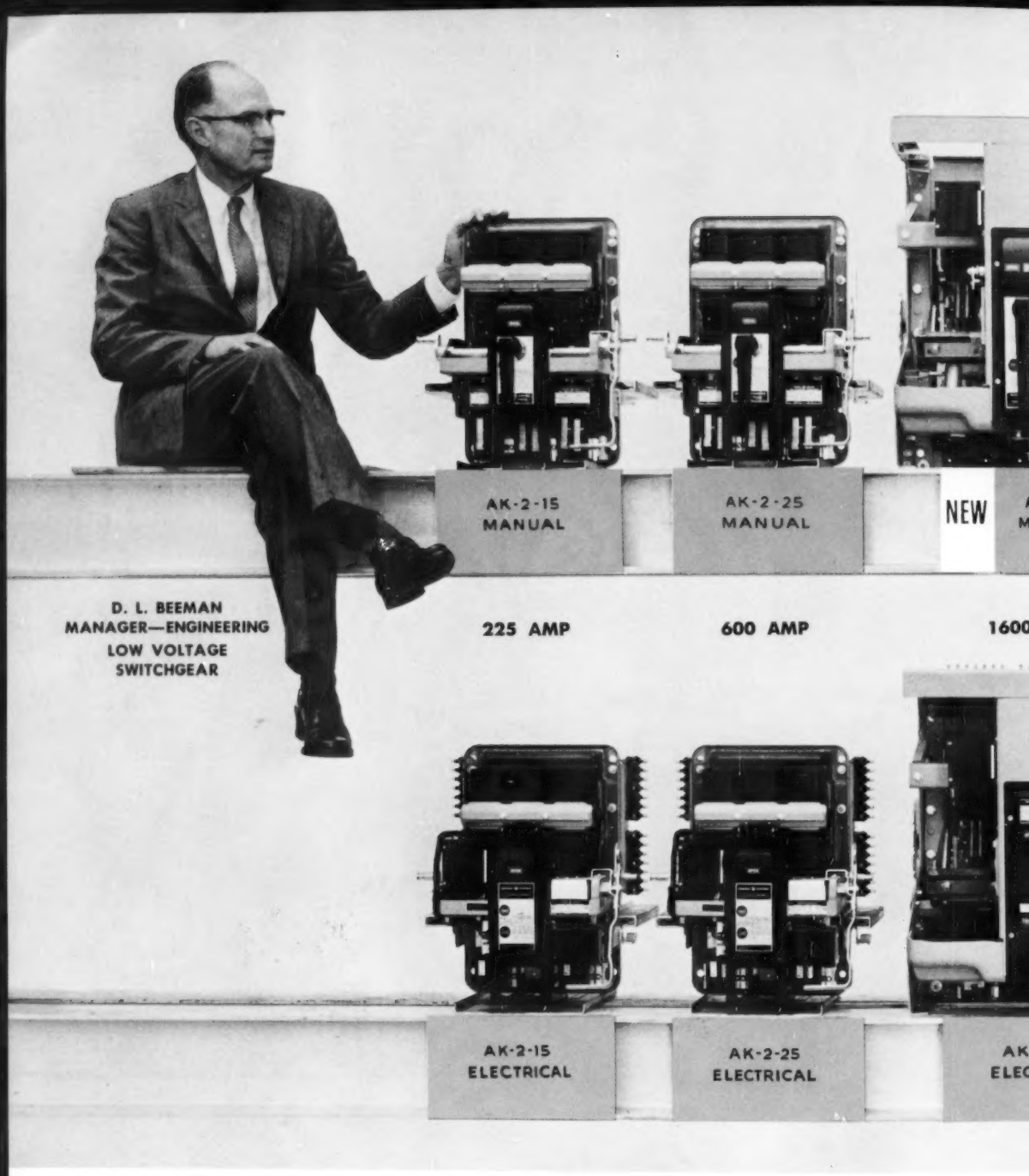

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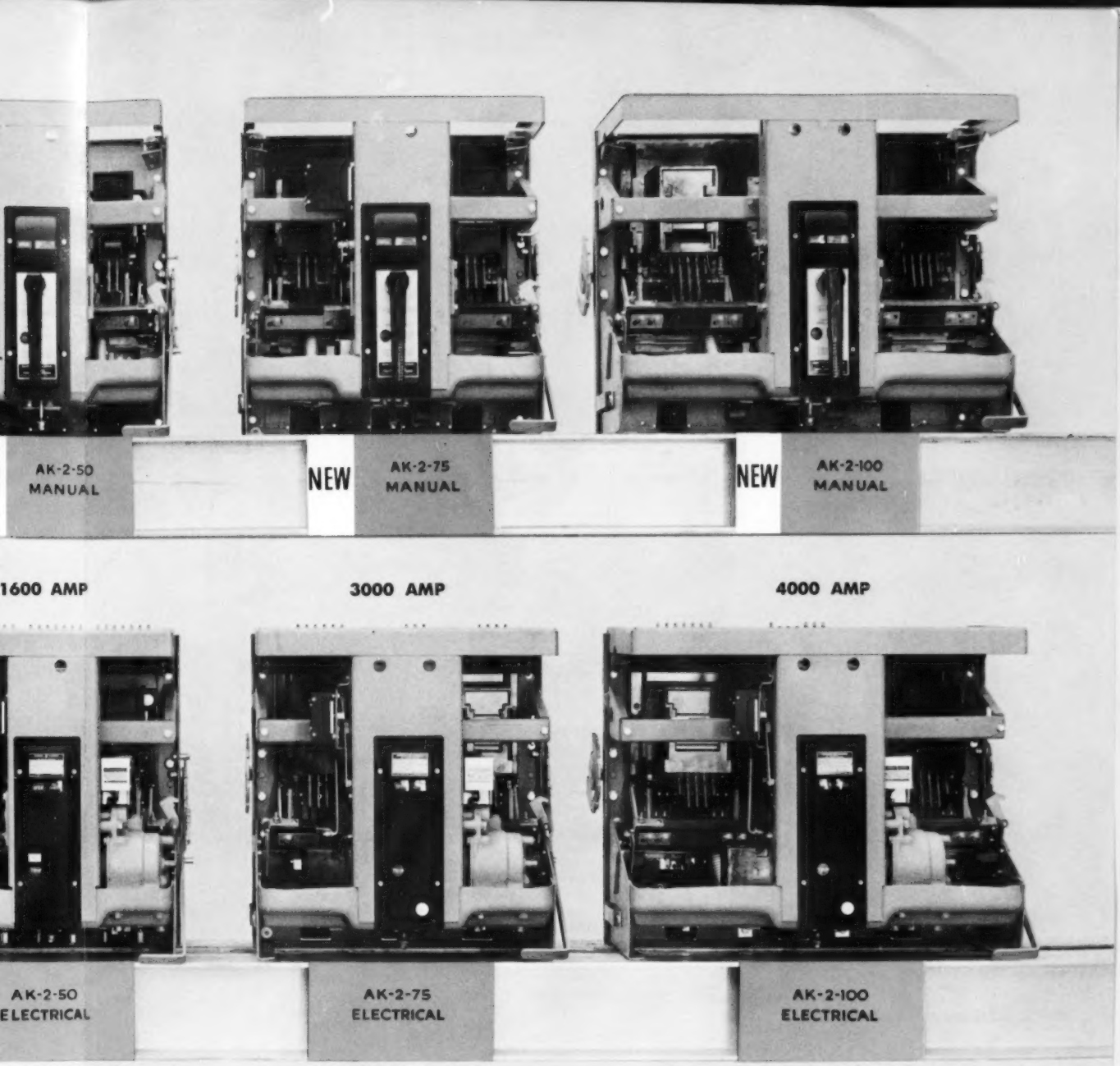

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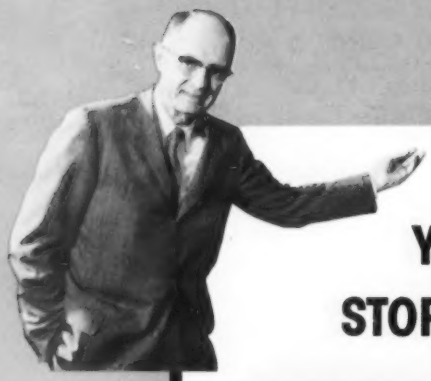

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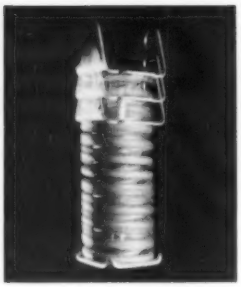

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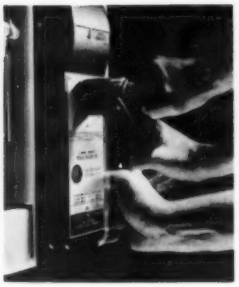

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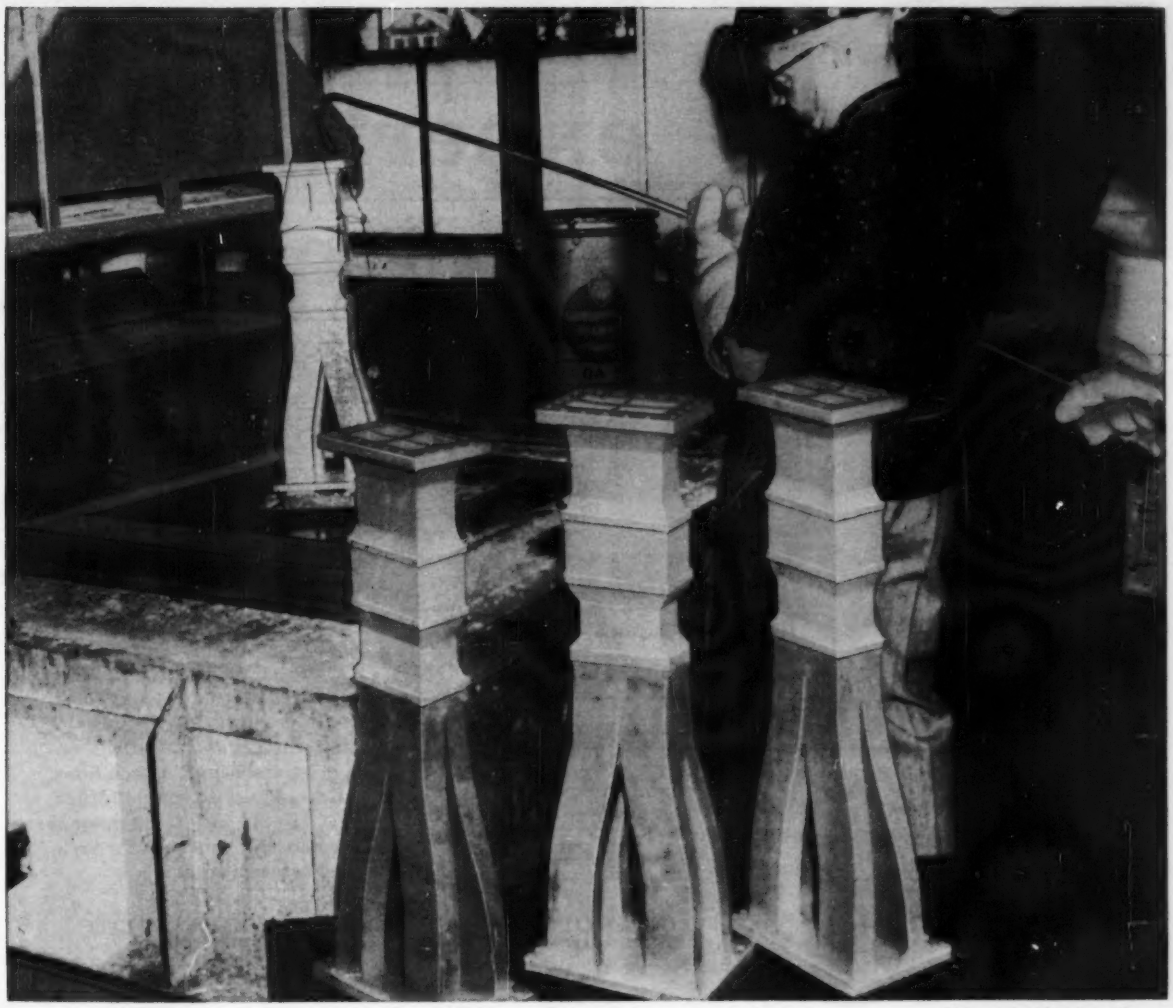

Photo courtesy of Raytheon Company

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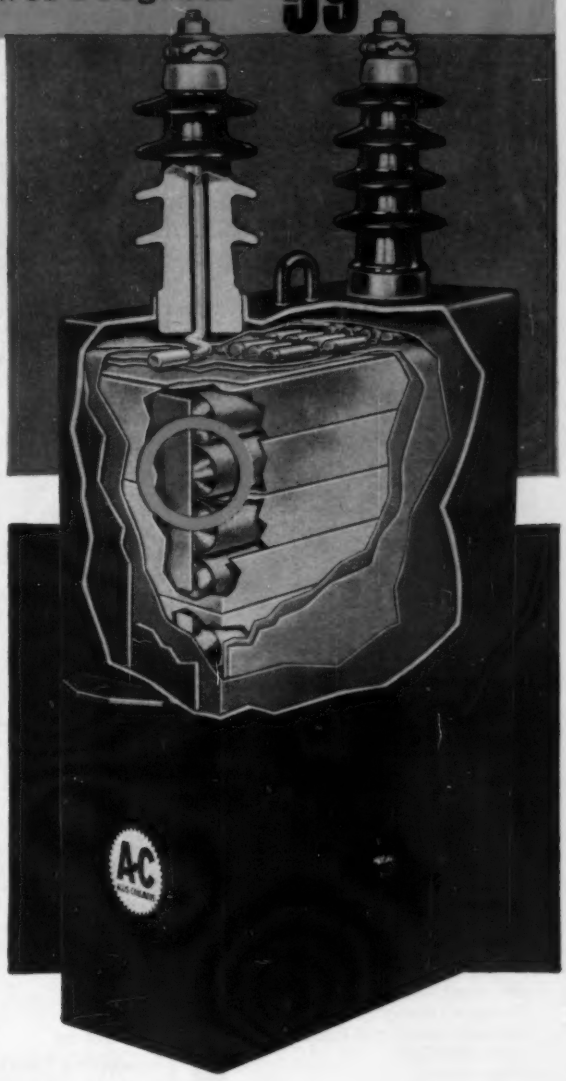

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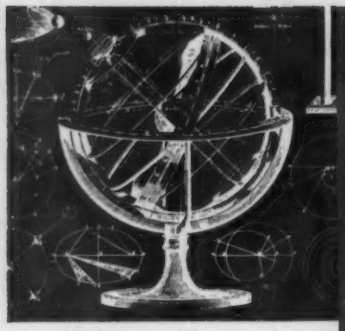

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Aeronautical Engineering:
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Physics and Mathematics:
Experimental Thermodynamics
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Computer Application Analysis
Computer Programming and Analysis
Mathematical Analysis

For full information write to:

Mr. C. C. LaVene
Box 620-Q
Douglas Aircraft Company, Inc.
Santa Monica, Calif.

Trade Literature...

Computer Bulletin . . .

A 6-page illustrated bulletin describes highlights of the Bendix *G-15* digital computer with particular emphasis on the magazine-loaded photo tape reader which is offered as standard equipment. Also included are descriptions of POGO and INTERCOM *1000* programming systems, accessory punched card, magnetic tape, and paper tape equipment, several special-purpose devices, and *G-15* specifications. **Bendix Computer Division, 5630 Arbor Vitae St., Los Angeles 45, Calif.**

Catalog on Unique Test Systems . . .

Automatic testing, microwave and antenna test instrumentation, radome testing systems, and flight simulation equipment are the four categories covered in a 12-page, 2-color catalog describing the entire product line of **California Technical Industries division of Textron, Inc., 1421 Old County Rd., Belmont, Calif.**

Brush Maintenance Manual . . .

This 16-page illustrated booklet (CP-3004) contains practical tips on brush operation and maintenance on high-current, low-voltage generators used in electrolytic processes. Included is a discussion of metal-graphite brushes used in plating generators, together with explanations of contact drop, friction, resistivity, and commutator surfacing. Other information for the electrical maintenance man includes sections on the facing-in of new brushes, dust removal, selective action, and factors affecting brush life. **National Carbon Co., 535 Fifth Ave., New York 17, N. Y.**

Booklet on Insulating Transformers . . .

Processes for insulating transformers to meet the grades of MIL-T-27A with Scotchcast brand epoxy resin are outlined in an 8-page booklet which is intended as a guide to the construction of transformers to military specifications, their design, and special techniques which have been successful in meeting such specifications. **Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul 6, Minn.**

Aluminum Tube Book . . .

A 48-page book entitled, "Revere Aluminum Tube," has been issued by Revere Copper and Brass Inc.; it draws upon the company's knowledge of aluminum and aluminum products and of nonferrous metals. Design engineers, architects, builders, and all other users of aluminum tube will find the book to be a valuable addition to their reference libraries because it contains comprehensive information on the selection of proper tube alloys, temper designations for aluminum tube, and resistance of alloys to various chemicals. Complete details are given in the book about the company's seamless drawn aluminum tube, aluminum extruded tube and pipe, welded aluminum tube, lockseam and butted aluminum tubes, and aluminum Tube-In-Strip. **Revere Copper and Brass Inc., 230 Park Ave., New York 17, N. Y.**

Cable Guide . . .

A wallet-size National Electrical Code Guide is available from **Columbia Cable & Electric Corp., 255 Chestnut St., Brooklyn 8, N. Y.**

Alcoa Structural Handbook . . .

This 420-page handbook supplies design information on the use of aluminum in structures. It is a sixth revision of the book, published originally in 1930, under the title "Structural Aluminum." The current revision involved changes in text, general up-dating of tables, and the addition of several new tables. Extensive data on the aluminum-magnesium alloys, and comprehensive coverage of welded structure design are included. **Aluminum Company of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa.**

Meter Catalog . . .

Expanded scale a-c and d-c voltmeters, expanded scale frequency meters, and linear scale ammeters are presented individually, and detailed from primer-like operating principles through complete specifications. Various meter case styles and sizes are illustrated in both photographs and drawings. **Helipot Technical Information Service, 2500 Fullerton Rd., Fullerton, Calif.**

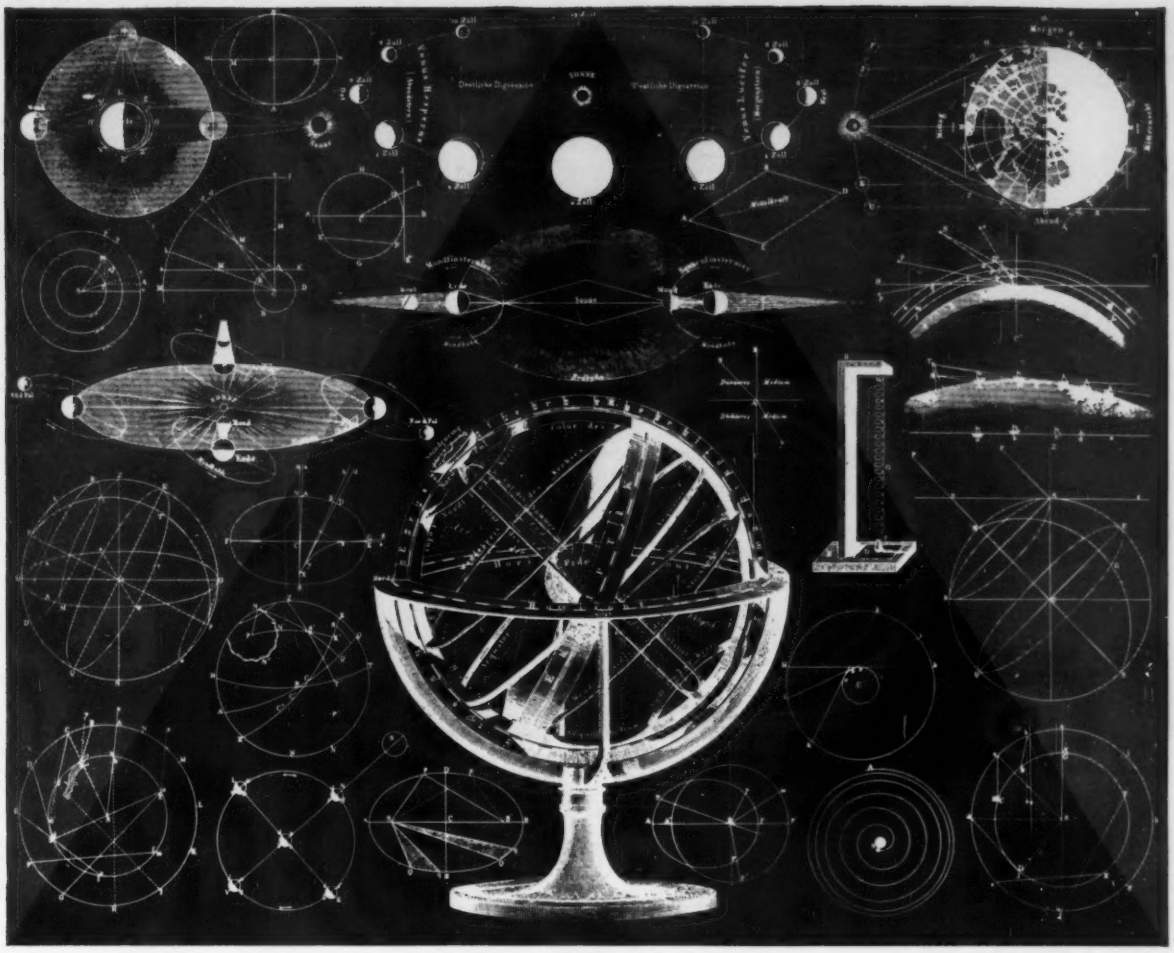
Flameproof Plastics Data . . .

Seven flame-proof and heat resistant diallyl phthalate plastic molding compounds for electrical and electronic use are featured in a 4-page specification sheet recently made available by **Mesa Plastics Co., 12270 Nebraska Ave., Los Angeles 25, Calif.**

Solenoid Actuated Digital Printer Pamphlet . . .

An informative 8-page pamphlet on solenoid actuated digital printers pertains to both high-speed serial and parallel entry printers and discusses applications, features, and specifications. **Victor Adding Machine Co., 3900 N. Rockwell St., Chicago 18, Ill.**

(Continued on page 61A)

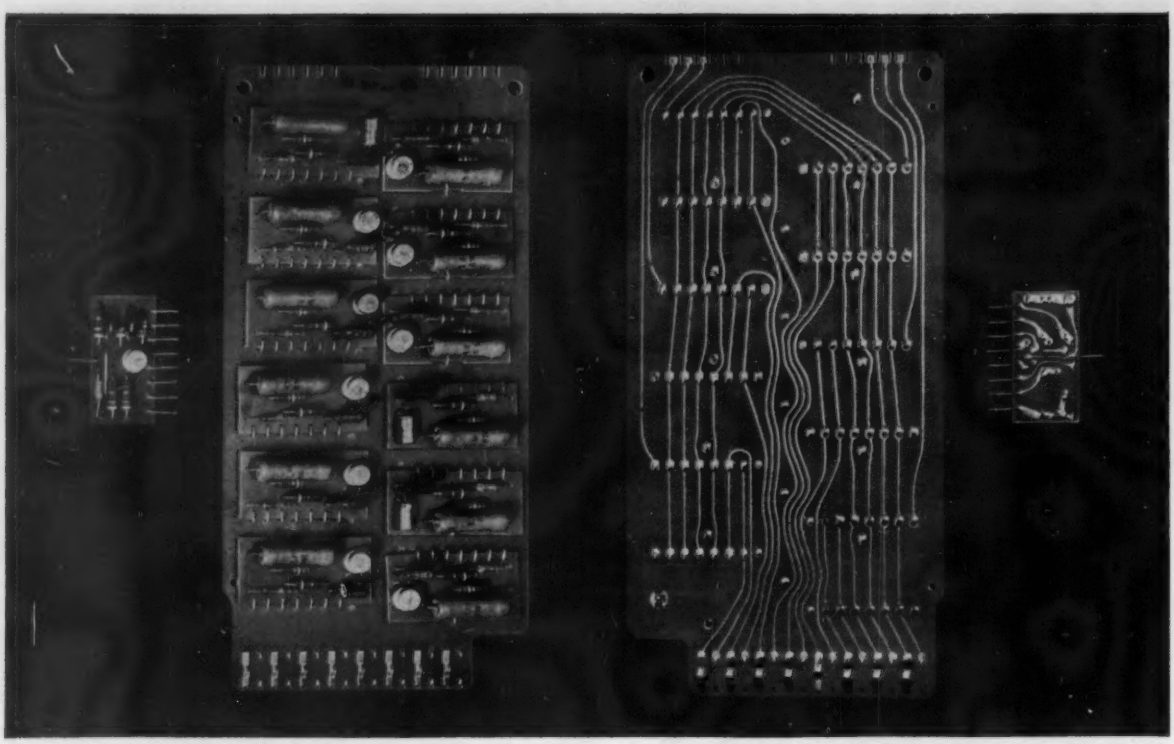


Guided tour of the solar system

The new NASA Thor-boosted research rocket, DELTA, now being constructed by Douglas, will set up big signposts for further space explorations. Combining elements already proved in space projects with an advanced radio-inertial guidance system developed by the Bell Telephone Laboratories of Western Electric Company, DELTA will have the versatility and accuracy for a wide variety of satellite, lunar and solar missions. Douglas insistence on reliability will be riding with these 90 foot, three-stage rockets on every shoot. At Douglas we are seeking qualified engineers to join us on this and other equally stimulating projects. Some of our requirements are listed in our column on the facing page.

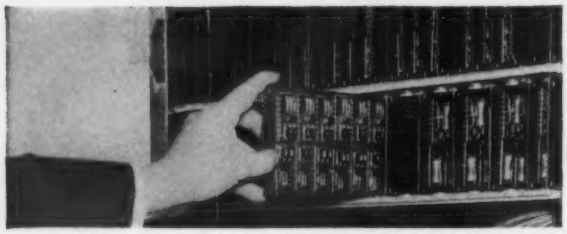
Maxwell Hunter, Asst. Chief Engineer—Space Systems, goes over a proposed lunar trajectory with Arthur E. Raymond, Senior Engineering Vice President of DOUGLAS

MISSILE SYSTEMS ■ SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND-HANDLING EQUIPMENT

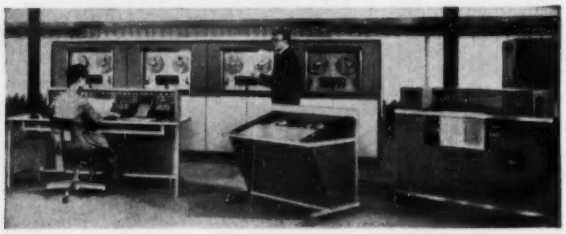


In the electronic logic elements of the RCA "501" data processing system, transistors and other small components are mounted on plastic wafers with printed-circuit wiring (small units right and left, above). The wafers, in turn, are mounted on thin plastic boards, also with printed circuits (center, above). This modular construction reduces size of the system by 75%, increases reliability, reduces maintenance.

PRINTED CIRCUITS OF COPPER AND ALL-TRANSISTOR DESIGN HELP MAKE 75% SIZE REDUCTION IN RCA DATA PROCESSOR



Modularized circuit elements are installed in the system by sliding them in place. Contacts on outside edge make possible quick checkout and testing without removing boards. Many thousands are used in each system.



The "501" is designed to handle paper work—bills, reports, payrolls, etc.—accurately, economically, and at extremely high speed. It serves businesses ranging from banks and utilities to steel mills.

With the growing importance of miniaturization and reliability in electronics and nucleonics, Anaconda electrical copper products take new and varied forms—find new and more sophisticated uses.

In the compact new all-transistor data processing system shown above, the printed circuits are etched from Anaconda "Electro-Sheet" copper foil. This is electrodeposited paper-thin copper with quality carefully controlled to meet NEMA specifications. Bright on one side, it has a matte finish on the other for a firm bond to the circuit board. "Electro-Sheet" is furnished in various thicknesses to exceptionally close tolerances.

In other fields, the growing need for compact electrical assemblies which can handle high current densities calls for hollow copper conductors for fluid cooling. And for new environmental conditions, more difficult application needs, there are new copper alloys.

METALLURGICAL ASSISTANCE. Whatever your problem in electrical conductors, Anaconda metallurgical specialists will gladly help you select the metal—and the form or shape—best suited to your needs. See your American Brass representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

5946

ANACONDA®

ELECTRICAL COPPER PRODUCTS

Made by The American Brass Company

For more information circle 42 on reader service card

Trade Literature

(Continued from page 58A)

Dielectric Materials Chart . . .

A colorful chart gives properties of dielectric materials at microwave frequencies over a wide range of dielectric constant and dissipation factor. **Emerson & Cuming, Inc., Canton, Mass.**

Transparent Silicone Potting Compound Brochure . . .

A silicone potting material that permits visual and instrument checking of individual parts within a potted assembly is described in a 4-page, illustrated brochure, 10-505. Designated as Dow Corning Dielectric Gel, this material cures in place to form a resilient, protective mass that retains its outstanding dielectric properties and moisture resistance over the wide temperature span of below −60 up to 200 C. In addition to tables of properties, the brochure includes a graph which shows at a glance that no damaging stresses are exerted on delicate parts by this material either during or after cure. **Dow Corning Corp., Midland, Mich.**

Stored Program Educational Computer . . .

Catalog S1 describes SPEC, a general-purpose digital computer and digital differential analyzer plus a logical design implementer. SPEC is specifically designed for educational usage, serious computation, experimentation, and demonstration of modern construction and hardware techniques. Because of plug-in logical elements used, the machine can be easily expanded. Operation codes, typical program, block diagram, physical components, and specifications are shown. **Computer Control Co., Inc., Western Division, 2251 Barry Ave., Los Angeles 64, Calif.**

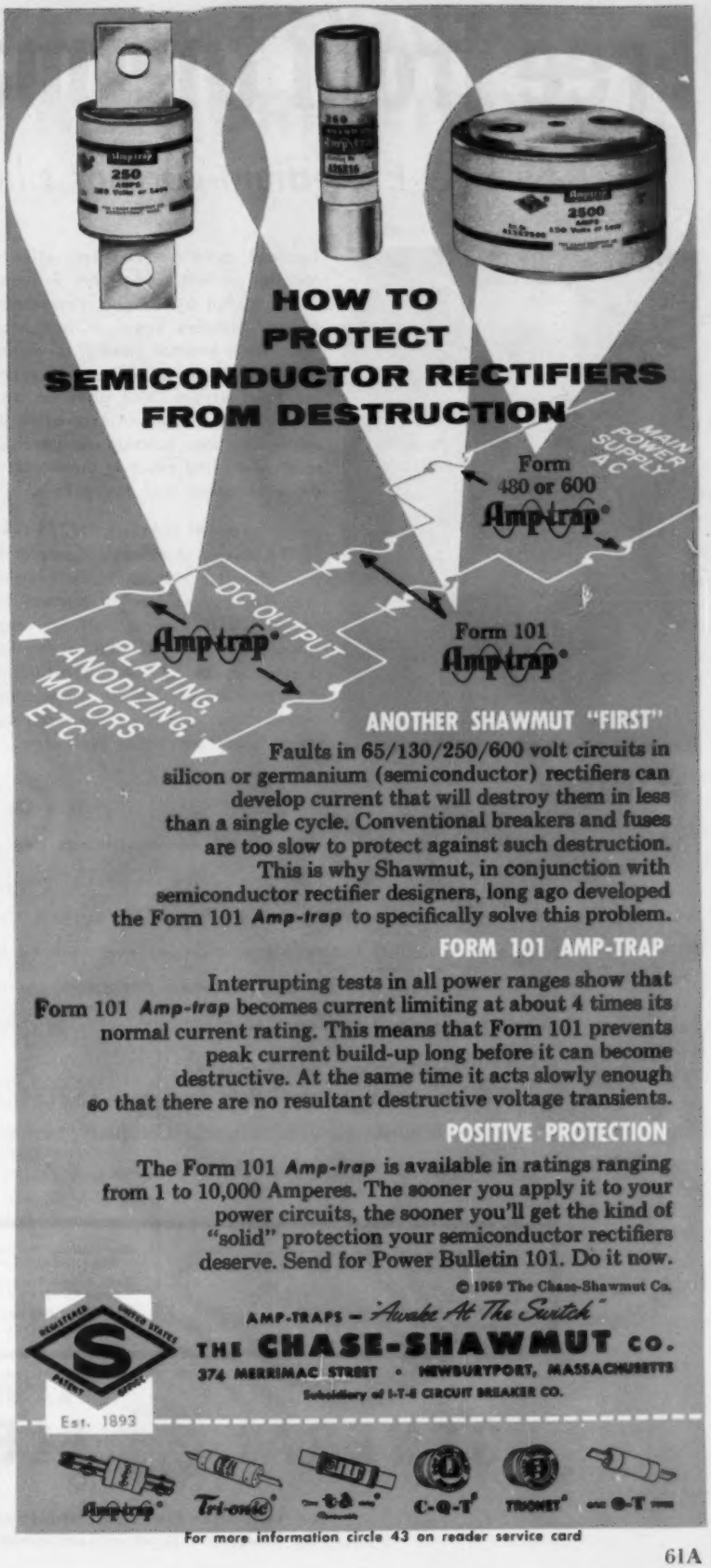
Bulletin on Plotters . . .

Bulletin PG-100, on a complete line of multichannel autographic plotters contains application data and complete specifications on Gilmore strain-gage plotters, modular plotter, and segmental recorder and scanner plotter. **Gilmore Industries, Inc., 13015 Woodland Ave., Cleveland 20, Ohio.**

Compresto Cables Brochure . . .

A 44-page brochure entitled "Southern Electrical's Growing Family of Compresto Cables," provides the latest available data for the use of Compresto covered cables as weatherproof line wire, duplex, triplex, and quadraplex. Also featured are data on the various coverings of neoprene, polyethylene, 2-coat, and the new high-density polyethylene. **Southern Electrical Co., P. O. Box 989, Chattanooga, Tenn.**

(Continued on page 64A)


HOW TO PROTECT SEMICONDUCTOR RECTIFIERS FROM DESTRUCTION
MAIN POWER SUPPLY A.C.
Form 480 or 600
Amp-trap
DC OUTPUT
PLATING, ANODIZING, MOTORS ETC.
Amp-trap
Form 101
Amp-trap
ANOTHER SHAWMUT "FIRST"
Faults in 65/130/250/600 volt circuits in silicon or germanium (semiconductor) rectifiers can develop current that will destroy them in less than a single cycle. Conventional breakers and fuses are too slow to protect against such destruction. This is why Shawmut, in conjunction with semiconductor rectifier designers, long ago developed the Form 101 Amp-trap to specifically solve this problem.
FORM 101 AMP-TRAP
Interrupting tests in all power ranges show that Form 101 Amp-trap becomes current limiting at about 4 times its normal current rating. This means that Form 101 prevents peak current build-up long before it can become destructive. At the same time it acts slowly enough so that there are no resultant destructive voltage transients.
POSITIVE PROTECTION
The Form 101 Amp-trap is available in ratings ranging from 1 to 10,000 Amperes. The sooner you apply it to your power circuits, the sooner you'll get the kind of "solid" protection your semiconductor rectifiers deserve. Send for Power Bulletin 101. Do it now.
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Est. 1893
AMP-TRAPS — "Awake At The Switch"
THE CHASE-SHAWMUT CO.
374 MERRIMAC STREET • NEWBURYPORT, MASSACHUSETTS
Subsidiary of I-T-E CIRCUIT BREAKER CO.
Amp-trap
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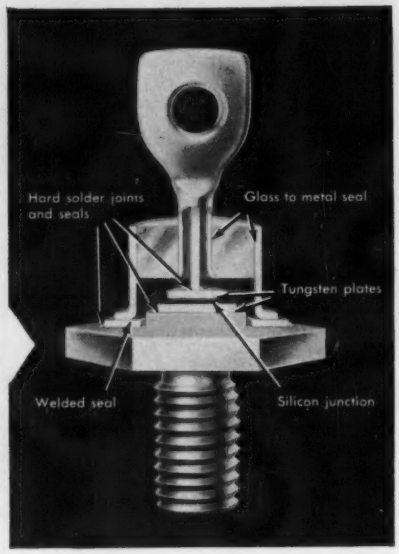
C-O-T
TRIONET
For more information circle 43 on reader service card

Free from thermal fatigue

New G-E medium-current silicon rectifiers

Typical medium-current silicon rectifier — Soft solders are first elements to fail by fatigue. Repeatedly stressed, solders begin to re-crystallize. When internal thermal resistance of device increases, temperature differential across joint goes up and causes even faster deterioration of solder. Finally, junction temperature reaches melting point or thermal runaway condition and device fails.

New General Electric 1N2154-60 series silicon rectifiers — Completely free of soft solder joints, both inside and out; proved free of thermal fatigue. 170°C cycling tests on large samples of the 1N2154 did not develop a single trace of thermal resistance deterioration at 30,000 temperature cycles. This is particularly valuable where loads are highly cyclical.



General Electric's new 1N2154-1N2160 medium-current silicon rectifiers completely eliminate a major pitfall of equipment design — thermal fatigue of internal solder joints. The new series offers the designer and equipment user these important advantages: (1) It can be worked right up to maximum current and junction temperature ratings, even on cyclical type loads. (2) A smaller heatsink can be used since no derating is necessary to compensate for thermal fatigue. (3) Thermal resistance remains constant, assuring long-term reliability.

For complete technical data on Series 1N2154, consult your G-E representative. Or write General Electric Company, Semiconductor Products Dept., Section S181159, Electronics Park, Syracuse, N. Y.

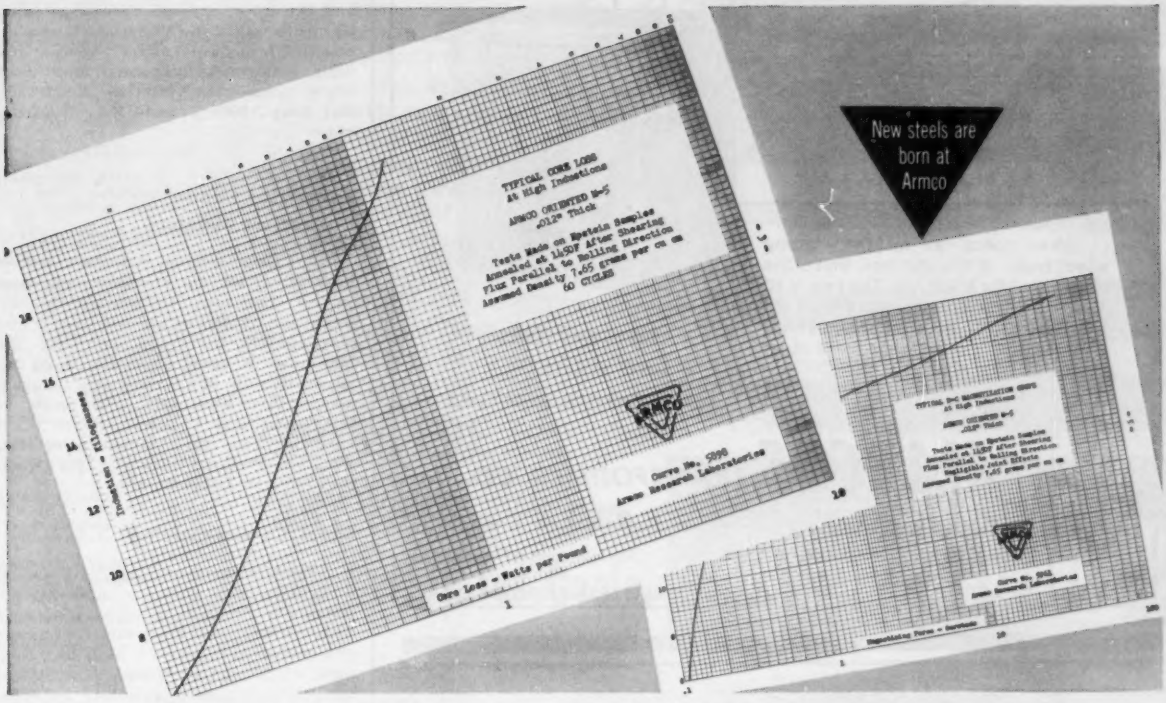
Max. Allow. Transient Peak Inverse Voltage (Non-re-current 5 millisec. max. duration)	100 to 800 volts	Max. Allow. Forward Current (Single Phase —145°C stud)	25 amperes
		Max. Allow. Peak One-cycle Surge Current	300 amperes
Max. Allow. Peak Inverse Voltage (Repetitive)	50 to 600 volts	Junct. Operating and Storage Temperature Range	—65°C to + 200°C

GENERAL ELECTRIC

Semiconductor Products Department

For more information circle 44 on reader service card

DESIGN DATA NOW AVAILABLE ON ARMCO'S NEW ORIENTED M-5



Design curves on magnetic properties of low core loss, high permeability Armco Oriented M-5 permit maximum use of its advantages.

New Armco Oriented M-5 has a maximum core loss of only .58 watts per pound at 60 cycles and 15 kilogausses. In addition, it has materially higher permeability at high inductions than any oriented silicon steel previously available.

To give designers the information they need to effectively utilize this special Armco Electrical Steel, its magnetic properties are detailed in a series of design curves. A Product Data Bulletin on Oriented M-5 contains curves on core loss, exciting RMS volt-amperes per pound, and d-c magnetization at both high and low inductions; d-c hysteresis loops at various peak inductions; a-c permeability; and other pertinent properties.

Get your copy of this Armco Bulletin and see how you can use this new Armco Oriented Electrical Steel to reduce the size and step up the efficiency of distribution and high performance transformers. Just write us or mail the coupon.

ARMCO STEEL CORPORATION
3239 Curtis Street, Middletown, Ohio

Send me a copy of your data bulletin on Armco Oriented M-5

Name_____

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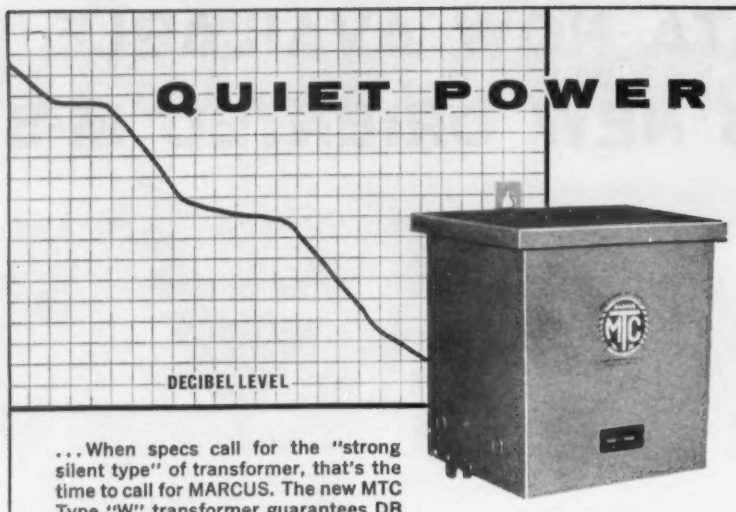
ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

For more information circle 45 on reader service card



...When specs call for the "strong silent type" of transformer, that's the time to call for MARCUS. The new MTC Type "W" transformer guarantees DB LEVELS THAT ARE BELOW NEMA STANDARDS. So for those extra quiet installations, Specify MARCUS---- Proven quieter by independent laboratory test.

- LOWER SOUND LEVELS
- LOWER WEIGHTS
- LOWER INSTALLATION COSTS

MARCUS TRANSFORMER CO., Inc.
RAHWAY, NEW JERSEY
"Mark of Quality"
Representatives in Principal Cities

A COMPLETE LINE OF DRY-TYPE AND LIQUID-FILLED TRANSFORMERS FROM 1 THROUGH 5000 KVA.

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Investigate the Widest Variety of Openings in Recent Years

at the Knolls Atomic Power Laboratory

For the first time in recent years, current openings here extend into disciplines generally considered outside of the traditional nuclear areas. As a result, excellent opportunities exist today for men interested in entering the nuclear field for the first time, as well as for recent graduates and, of course, experienced nuclear engineers and scientists. If you've been thinking of exploring professional opportunities at KAPL, we suggest you make your initial inquiry today.

Current Openings:

- Primary & secondary systems design
- Reactor operation
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- Powerplant performance evaluation
- Powerplant & reactor instrumentation
- Powerplant & reactor controls
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- Electronic equipment development

U. S. Citizenship Required

Forward your resume in confidence, including salary requirement. Please also state your job interests. *Address:* Mr. A. J. Scipione, Dept. 27-MK.

Knolls Atomic Power Laboratory
OPERATED FOR A.E.C. BY
GENERAL ELECTRIC
Schenectady, N. Y.

Trade Literature

(Continued from page 61A)

X-Ray Catalog . . .

A 112-page accessories and supplies catalog listing more than 1,500 items used by radiologists and X-ray laboratories is divided into nine sections devoted to films and chemicals; opaques; cassettes, screens, and grids; tanks and dryers; darkroom accessories; protective materials; viewing and filing; radiographic accessories; and fluoroscopic accessories. **Tracerlab, Keleket X-Ray Corp., 1601 Trapelo Rd., Waltham, Mass.**

Equipment Control Connectors Bulletin . . .

A 12-page bulletin contains complete information on the new Joy equipment control connectors. Constructed of neoprene, the connectors are said to offer the maximum in safety and durability, the minimum in maintenance. Designed for applications up to 600 volts, they are available in three basic styles: oval, round, or dual round, 2 to 12 poles. Bulletin 372 is available from **Joy Manufacturing Co., Electrical Products Division, 1201 Macklind Ave., St. Louis 10, Mo.**

Shock Control Catalog . . .

This comprehensive technical manual designed to assist engineers in solving objectionable vibration and shock conditions with Sorbtex preformed fabric neoprene and rubber pad materials, contains a complete set of reference charts and text developed by extensive laboratory tests conducted over a period of many months. **Voss Engineering, Inc., 5649 N. Ravenswood Ave., Chicago 26, Ill.**

Carbon-Brush Reprints . . .

Reprints of "Brush Operating Properties," a recent technical article describing carbon-brush characteristics that affect the performance of electric machines, can now be obtained from **Carbon Products Division, Speer Carbon Co., St. Marys, Pa.**

Feed Water Control Bulletin . . .

Two-element and single-element air-operated feed water control systems are illustrated by diagrammatic drawings in new 4-page Bulletin 531. To aid in the selection of the proper system for each application, a simplified chart is included. **Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.**

Electrical Connectors Catalog . . .

An informative 88-page catalog on electrical connectors is available from Amphenol **Electronics Corp., 2801 S. 25th Ave., Broadview, Ill.**

Circle 47. ►

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672 Whitehall Street S. W.

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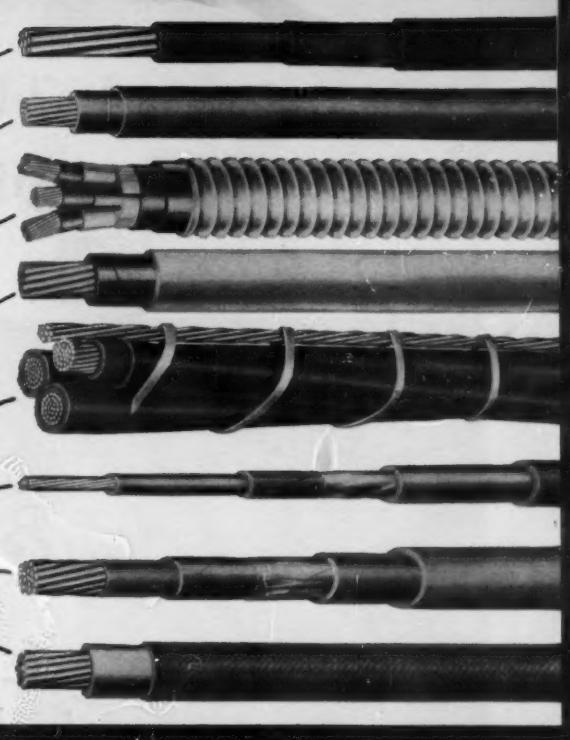
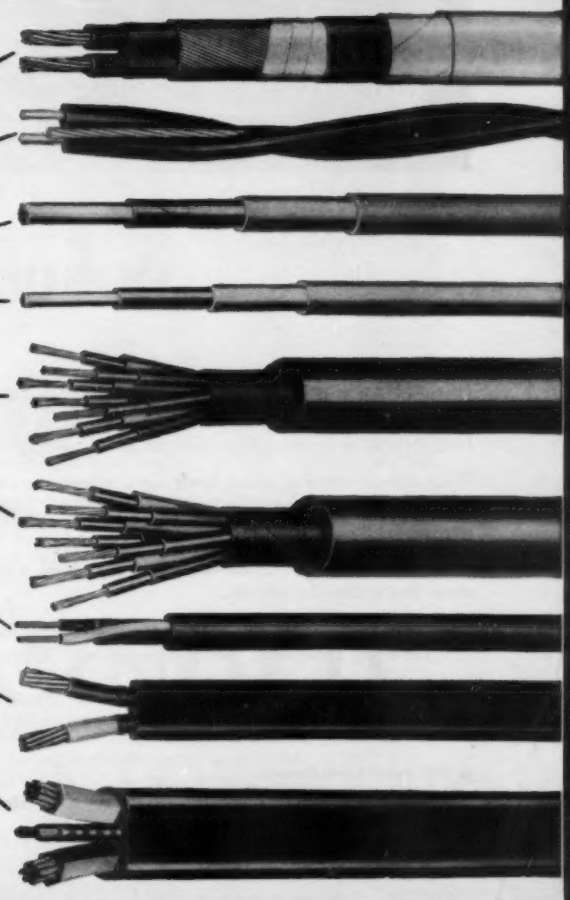
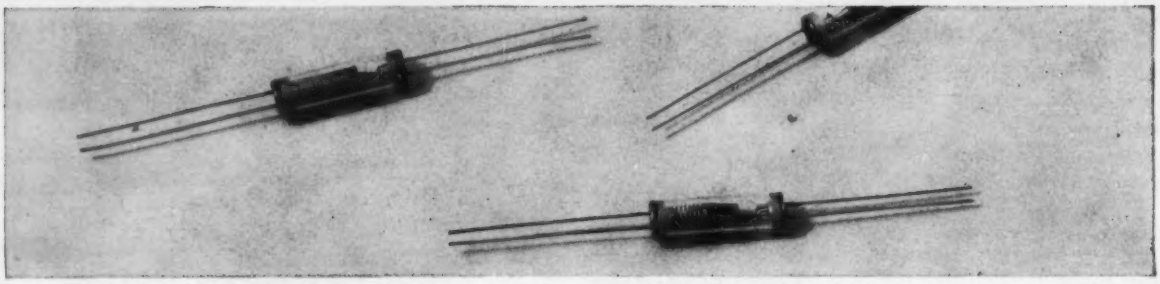

Collyer RHW
Collyer Style RR (RHW Insulation)
Collyer Style RR (Butyl Insulation)
Collyer VCB with or without interlocking armor
Collyer VCL with or without protective neoprene sheath
Collyer Self-Supporting Aerial Cable (Butyl Insulation)
Collyer Type AVA
Collyer Type AVL
Collyer Silicone Power Cable

ANYWHERE...
ANY KIND...When the Call is for Cable, CALL FOR Collyer


Collyer SE Style U or A
Collyer Neutral Supported Service Cable
Collyer Type AVB
Collyer Type TA
Collyer C-141 (Polyethylene, Nylon, PVC)
Collyer RR Control Cable (Oil Base Insulation)
Collyer SJ or SJO, Light Duty
Collyer S or SO, Heavy Duty
Collyer Type W
Collyer Type G

HUGHES THERMAL RELAYS



FOR RELIABILITY

IN GUIDED MISSILES

Hughes now makes commercially available a completely reliable single action switch. Used in the Falcon, field proven as a reliable missile, this Hughes relay is engineered to meet the most exacting of requirements.

With unusual speed of action, firing signal triggers the release of constrained contact...contact closes upon fixed contact point...switch circuit becomes permanently closed.

In a typical application, 3.0 volts DC applied to a firing circuit of 1.2 ohms fires within 0.3 seconds.

For additional information please write: Hughes Semiconductor Division, Marketing Department, 500 Superior Avenue, Newport Beach, Calif.

SPECIFICATIONS

MECHANICAL—Body Size: Maximum diameter 0.252"; length .920". Total weight: Less than 0.1 oz.

ELECTRICAL—Before Firing: Insulation resistance is greater than 200 megohms. Minimum breakdown voltage 600 volts.

Firing: 2 volts minimum required. Actual voltage dependent upon closing time desired.

After Firing: Circuit resistance less than 0.3 ohm.

ALTITUDE—Any.

OPERATING TEMPERATURE: −55°C to +125°C.

SEMICONDUCTOR DIVISION

Creating a new world with ELECTRONICS **HUGHES PRODUCTS**

© 1958, Hughes Aircraft Company

For more information circle 48 on reader service card

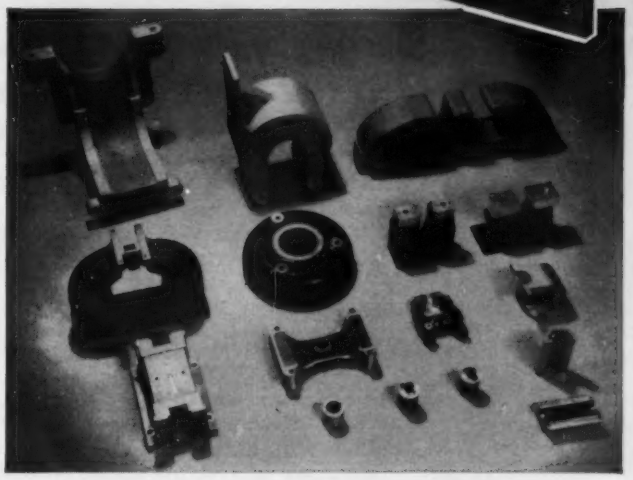
Arnold Builds World's Largest Permanent Magnet...Used in Atomic Research

Vital Statistics on the Big Magnet

Here's how the world's champion permanent magnet weighed in: 1720 pounds of Alnico V in the assembly . . . a keeper weighing 225 pounds . . . a total shipping weight of a little over 2 tons.

Overall dimensions of the magnet assembly, as illustrated at right, were 52½" x 36" x 10", with a gap length of 16.5". The gap volume was 1584 cu. inches, and the density at the center of the gap was 1100 gausses.

Approximately 500,000 ampere turns were required to magnetize the big unit, which was shipped magnetized and keepered. It was designed for use in auxiliary equipment serving a breeder reactor for the Argonne National Laboratory, operated by the University of Chicago for the U.S. Atomic Energy Commission. Actual service is in an electro-magnetic pump for pumping fluid metals.



Top: the world's largest permanent magnet, built by Arnold for Argonne Labs, was designed to supply a field of 1100 gausses in a gap of 16½ inches. Bottom: a typical group of the permanent magnet assemblies that Arnold supplies for rotors, traveling wave tube, wave guide and magnetron magnets, mass spectrometer and other measuring applications, etc.

Vital Suggestion for Your Requirements

The facilities and wealth of experience that produced this world's largest permanent magnet are ready to bring you advantages, too.

Arnold permanent magnets are available in all types of Alnico and other magnet materials, from large castings like the Argonne unit to very small sintered parts weighing less than a gram. Many sizes and types of Alnico magnets are carried in stock for immediate delivery.

Special assemblies—such as rotors, traveling wave tube and magnetron magnets, etc. —may be supplied jacketed to facilitate mounting and give added protection to the magnet. Arnold also can supply large magnet assemblies for mass spectrometer and other measuring applications, where a high degree of stability and uniformity of field is required.

● Ask for a copy of Bulletin GC-106C, for more information on Arnold permanent magnets and other products, (tape cores, powder cores, etc.) Write *The Arnold Engineering Company, Main Office and Plant, Marengo, Illinois.*

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We Were Created to Create . . .

SYSTEMS. Not just electronics.

The systems we foresee will establish new dimensions: In "gaming" and logistical data processing; Undersea; Communications; Continental air defense, ground support; IPV (interplanetary vehicle) control; Missile, Satellite Check-out; Our RAMP microwave platform. And, a variety of non-military systems.

We seek men to generate these systems.

Most are outstanding systems or project engineers. Some are physicists. A few are geo-political analysts.

Each is a broad thinker, experienced at systems planning, hardware, analytical approaches. Aware of the increasing electronic content of systems, each knows that the minds which comprehend this content determine the future influence of systems upon civilization.

To these men, Raytheon's new SYSTEMS MANAGEMENT offers unparalleled professional satisfaction. They are invited to inquire of: Mr. Donald Sweet, Engineering & Executive Placement, Raytheon Company, 624P Worcester Road, Framingham, Mass. (suburban Boston).

SYSTEMS MANAGEMENT

GOVERNMENT EQUIPMENT DIVISION

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PROGRESS IN PLASTICS

THE TROUBLE WITH PRINTED CIRCUITS— AND HOW CDF WORKS TO SOLVE IT

The honeymoon is long since over; suppliers and manufacturers are engaged now in the humdrum activity of making printed circuits *work*. The industry found in time that there was still a long way to go before the *magic* of printed circuitry was proved incontrovertibly in practice. The truth: Too many mass-produced printed circuits simply were no good. Why?

The trouble was not in the theory. Or in approved manufacturing techniques. It lay—and still lies—in raw materials, primarily in the consistency of quality of base laminates.

We're not here to say that CDF has a totally rosy record in this field. No, we've had our share of failures along with our many triumphs. In fact, our failures during the early years of copper-clad laminates taught us certain important things that our competitors have yet to learn.

But we do emphasize this: We've made—and are still making—great progress at CDF in licking problems that have beset the printed-circuit producer and the printed-circuit user in obtaining top-quality laminates on every order, regardless of grade.

Here, for example, are a few areas where CDF R&D has been particularly active:

1. Consistent quality. A major cause for printed-circuit rejects has been delamination and blistering of the base laminates when subjected to high temperatures in processing. New developments in CDF raw-materials control promise a heartening break-through in this respect. Also, CDF technical personnel are engaged in counseling circuit manufacturers in optimum handling and processing techniques.

2. Foil-bond strength. Certain metal-clad laminates seem to pass the most rigid laboratory tests, only to fail at the end of manufacture when dipped in solder or when put through long-term operational tests at elevated temperatures. The foil-bonding strength of CDF Di-Clad® laminates, however, is recognized throughout the industry as superior in every grade.

Nevertheless, improvements are being made daily in foil adhesives and bonding methods at CDF, and bond strengths are being increased—not only in number of pounds required for foil separation, but in length of safe solder-immersion and high-temperature operation time.

3. Range of selection. CDF has consistently offered the widest range of metal-clad grades—in phenolic and epoxy paper-base, epoxy-glass, and Teflon*-glass. And CDF Di-Clad Teflon-glass grades remain the only laminates of their kind approved by the military. CDF Technical Bulletin 11,900 gives the latest information on all Di-Clad printed-circuit grades.

* du Pont's TFE fluorocarbon resin

4. Flexible grades. Newly-perfected *flexible* grades of CDF Di-Clad promise the designer even greater freedom. One of the headaches in the use of printed circuits has been their rigidity. They tend to hamper independent movement and vibration of connected systems. They occasionally dictate inconvenient housing shapes. Flexible printed circuits, however, overcome these objections and provide many additional benefits of their own. Details on how CDF flexible Di-Clad materials can help see you out of a printed-circuit problem can be obtained from your CDF sales engineer. Look up his phone number in the Product Design File (Sweet's), Electronics Buyers' Guide, or your own CDF catalog. Or send us your print or your problem, and we'll return recommendations based on your individual needs.

NEW CDF LITERATURE

Information on new grades, special applications, and outstanding properties of CDF insulating materials is made available regularly through CDF Technical Bulletins and Folders. The following literature is new. For copies of any bulletins listed, send the coupon below.

CDF Di-Clad Laminates—
Bulletin 11,900

CDF Skived Tapes of Teflon—
Bulletin 97

CDF Pressure-Sensitive Tapes of Teflon
Bulletin 102

CDF Grades Meeting NEMA, ASTM, Federal, and Military Specifications—
Bulletin 10,100

CDF Dilecto® Paper-Base Laminates—
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Weighs only 13½ lbs. without batteries.
Batteries weigh 2 to 4 lbs.
Size only 5¾" x 8¼" x 16".

HIGH PERFORMANCE

Vertical Response: DC to 5 MC, 0.07 μsec risetime.
Calibrated Sensitivity: 0.01 v/div to 20 v/div in 11 calibrated steps. Continuously adjustable from 0.01 v/div to 50 v/div.
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Simplified Triggering: Fully automatic, or amplitude-level selection with preset stability control.
4-KV Accelerating Potential on 3" crt.
6-div by 10-div Display Area.
Amplitude Calibrator.

NO POWER SOURCE PROBLEMS

Operates from:

1. Ten size D Flashlight cells, ½ hour continuous, more with intermittent, operation.
2. Ten rechargeable cells, 2.5AH—3 hours continuous operation. Ten rechargeable cells, 4.3AH—5 hours continuous operation.
3. 11 to 35 v dc (aircraft, auto, boat, etc.).
4. 105 to 125 v ac or 210 to 250 v ac, 50 to 800 cps.

Price	**$775.00**
Built-in Battery Charger	**35.00**
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Tektronix is represented in 20 overseas countries by qualified engineering organizations.

ENGINEERS—Interested in furthering the advancement of the oscilloscope? We have openings for men with creative ability in circuit and instrument design, cathode-ray tube design, and semiconductor research. Please write Richard Rapiequet, V.P., Eng.

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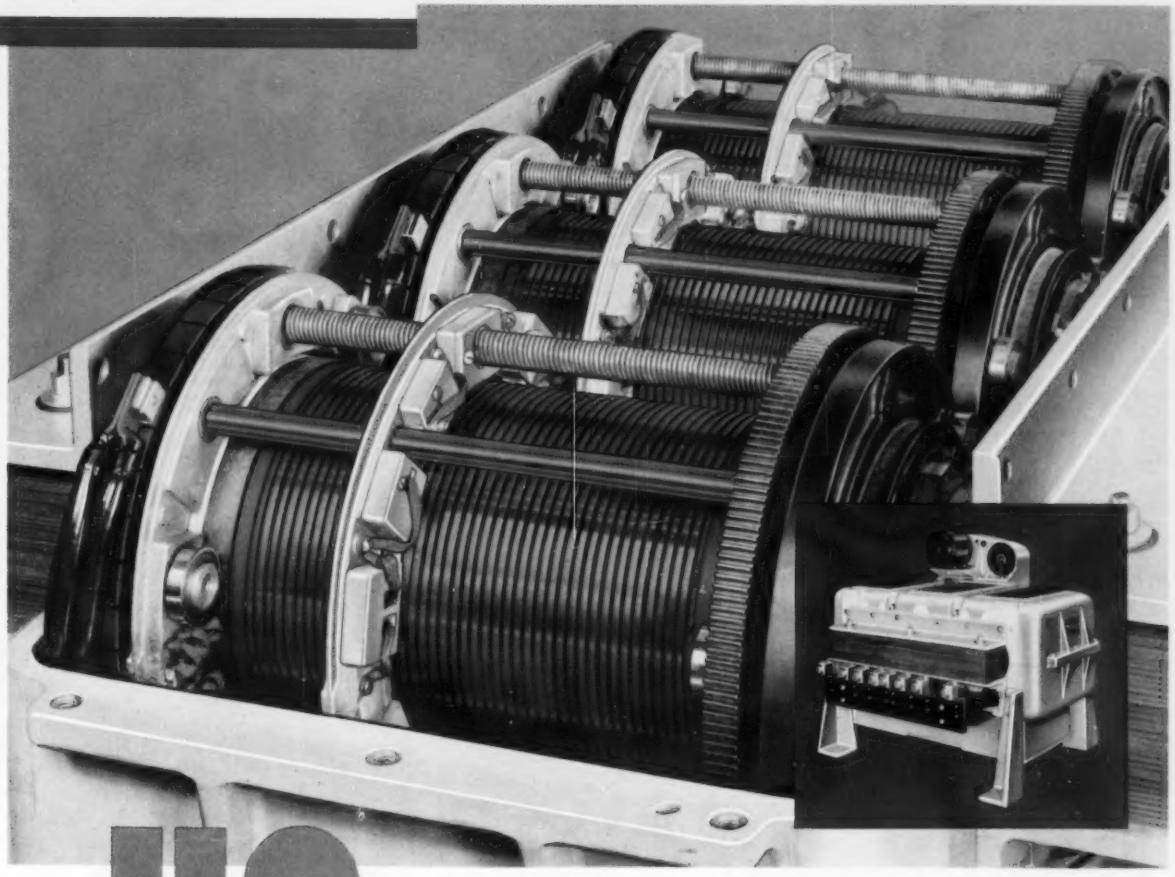
Circle 53 ➤

A COMPLETELY NEW CONCEPT *in variable transformer design!**



the **HC** *series* **POWERSTAT®** *variable transformers*

HIGH CURRENT CAPACITY
— The use of a helical wound coil design instead of the conventional toroidal wound coils permits current capacities much higher than previously available in variable transformers.

EXTREMELY FINE ADJUSTMENT
— Patented re-entry rings permit continuously-adjustable control of 1600 increments over the range of zero to maximum output voltage. Resolution is better than 1/10 of 1% of the input voltage.

HIGHEST EFFICIENCY
— Low resistance brushes are always in contact with only one turn of the helical wound coil resulting in very low voltage drop.

PLUS:

ZERO WAVEFORM DISTORTION, EXCELLENT REGULATION, SMOOTH CONTROL, CONSERVATIVE RATINGS, LINEAR OUTPUT VOLTAGE, LOW COST PER KVA.

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Bristol, Connecticut, U.S.A.

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• *such high efficiency* • *such fine adjustment*
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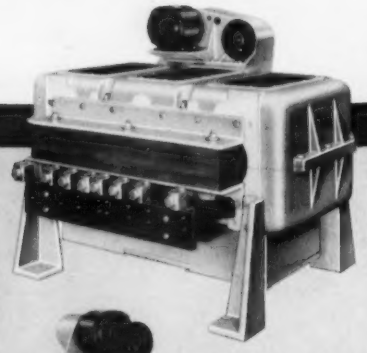
for heavy duty applications requiring cool, efficient operation



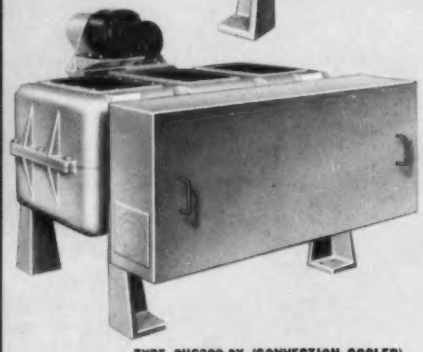
TYPES

Two 240 volt, 3-phase types are offered. Type 2HC200-3Y is cooled by normal convection. Type 2HCB200-3Y is similar in construction but incorporates fans for forced air cooling of the coils. Output rating of the forced air cooled type is nearly double that of the convection cooled type. Types for 480 volt, 3-phase duty are available also.

POWERSTATS *of the H-C Series can be remotely operated from a control unit mounted either on the POWERSTAT frame or at any other convenient location. Raise-lower signals from the control unit operate the adjustable speed motor driving the contact brush assembly. Full range travel speed is fully adjustable between 15 seconds and 10 minutes. Travel is smooth with fast starting and stopping at any voltage setting. Integrally mounted travel limit switches provide stops and unit protection.*

TYPE 2HCB200-3Y (FORCED AIR COOLED)

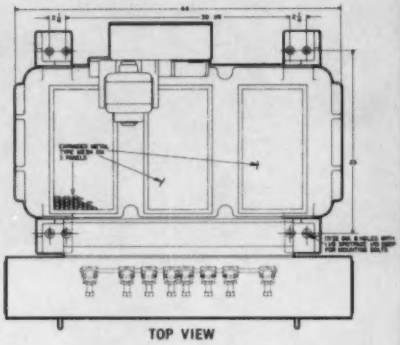
INPUT:	240 VOLTS	60 CYCLES	3 PHASE
OUTPUT:	0-270 VOLTS	360 AMPERES	168 KVA



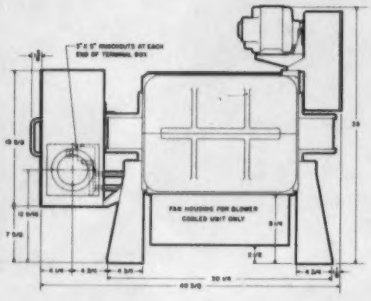
TYPE 2HC200-3Y (CONVECTION COOLED)

INPUT:	240 VOLTS	60 CYCLES	3 PHASE
OUTPUT:	0-270 VOLTS	200 AMPERES	93.5 KVA

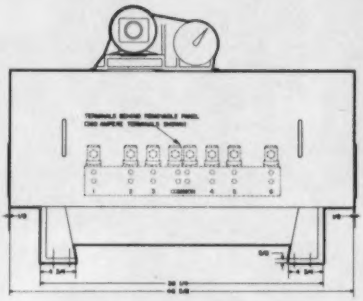
OUTLINE DIMENSIONS



TOP VIEW



SIDE VIEW



FRONT VIEW

THE SUPERIOR ELECTRIC COMPANY, Bristol, Connecticut

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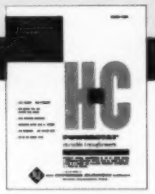
Request H-C Series Bulletin giving full technical information, ratings and specifications.



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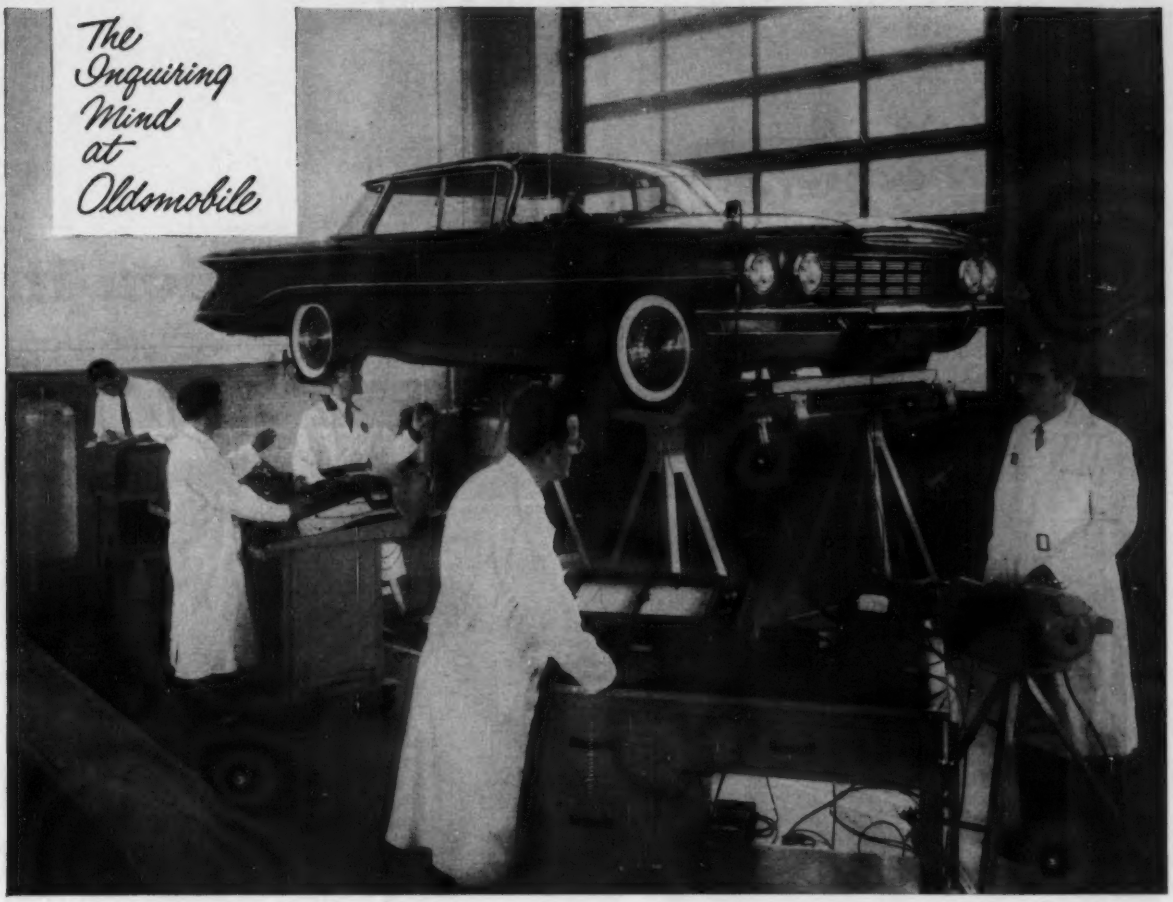


no. 10 OF A SERIES

IT'S THE QUIETEST RIDE YOU'VE EVER TRIED!

New Vibra-Tuned Body Mountings—electronically located at the nodal points of the frame by Oldsmobile engineers—produce an exceptionally quiet and satisfying ride.

Quietness in a fine automobile is a mark of superior quality. To make the 1960 Oldsmobile the quietest, most comfortable car on the road, Oldsmobile engineers have developed many advanced testing techniques to insulate against all types of road noise.

One of the unique ways in which noise and vibration are isolated by Oldsmobile engineers is through Vibra-Tuned body mountings. These mountings—direct attaching points between the body and frame—are critical to comfort and to the life of the car. If they are not properly placed, severe road vibrations can literally shake the car apart in a few thousand miles. But, by using the most advanced electronic measuring techniques, a softer and quieter ride is achieved by placing the body mounts at the nodal points of the frame. In this way, inherent road vibrations and shocks are practically isolated from the passenger compartment.

In the "tuning" of the chassis and body, the car is subjected to severe shaking, at a frequency of 7½ to 15 cycles per second, by a mechanical oscillator to produce torsional and bending moments. By using numerous electronic pick-ups, movement of the frame and body at a given point can be determined quickly and translated into an accurate magnitude vs. frequency curve through an X-Y plotter. By a complete and thorough examination of the entire car in such a manner, it can be determined where the "dead" or nodal points are on the frame, and the body mounts can then be scientifically placed. Then, after being located, the hysteresis characteristics of the body mounts are determined to give the most satisfying ride.

These methods, and many more up-to-the-minute techniques, have enabled Oldsmobile engineers to build consistently fine quality automobiles year after year. Visit your local authorized Quality Dealer and drive a 1960 Oldsmobile. See why it's the most satisfying car you've ever known . . . *the finest the medium-price class has to offer!*

OLDSMOBILE DIVISION • GENERAL MOTORS CORPORATION

OLDSMOBILE **Where Proven Quality Is Standard!**

For more information circle 54 on reader service card

A new dimension in

bubble blowing

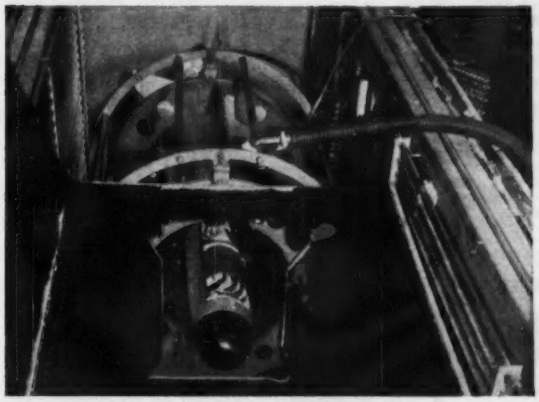
This plastic bubble protects the antenna of a radically new aerial three-dimensional radar defense system.

Sensitive to the inadequacies of conventional radar systems, engineers at Hughes in Fullerton devised a radar antenna whose pointing direction is made sensitive to the frequency of the electromagnetic energy applied to the antenna. This advanced technique allows simultaneous detection of range, bearing and altitude...with a single antenna.

Hughes engineers combined this radar antenna with "vest-pocket sized" data processors to co-ordinate antiaircraft missile firing. These unique data processing systems provide:

1. Speed—Complex electronic missile firing data was designed to travel through the system in milliseconds, assuring "up-to-date" pinpoint positioning of hostile aircraft.
2. Mobility—Hughes engineers "ruggedized" and miniaturized the system so that it could be mounted into standard army trucks which could be deployed to meet almost any combat problem—even in rugged terrain.
3. Reliability—By using digital data transmission techniques, Hughes engineers have greatly reduced any possibility of error.

Result: the most advanced electronics defense system in operation!



Falcon air-to-air guided missiles, shown in an environmental strato chamber are being developed and manufactured by Hughes engineers in Tucson, Arizona.

Reliability of the advanced Hughes systems can be insured only with the equally advanced test equipment designed by Hughes El Segundo engineers.

Other Hughes projects provide similarly stimulating outlets for creative talents. Current areas of Research and Development include advanced airborne electronics systems, advanced data processing systems, electronic display systems, molecular electronics, space vehicles, nuclear electronics, electroluminescence, ballistic missiles...and many more. Hughes Products, the commercial activity of Hughes, has assignments open for imaginative engineers to perform research in semiconductor materials and electron tubes.

Whatever your field of interest, you'll find Hughes diversity of advanced projects makes Hughes an ideal place for you to grow...both professionally and personally.

Newly instituted programs at Hughes have created immediate openings for engineers experienced in the following areas:

Infrared	Thin Films
Plasma Physics	Microwave Tubes
Digital Computers	Circuit Design & Evaluation
Field Engineering	Systems Design & Analysis
Quartz Crystal Filters	Logical Design
Communications	Semiconductor Circuit Des.

Write in confidence to Mr. Mike Welds
Hughes General Offices, Bldg. 6-B11, Culver City, Calif.

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These items are listings of the Engineering Societies Personnel Service, Inc. This Service, which cooperates with the national societies of Civil, Electrical, Mechanical, Mining, Metallurgical, Petroleum, and Chemical Engineers, is available to all engineers, members and non-members, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 5% of the first year's salary if a non-member, or 4% if a member. Also, that you will agree to sign our placement fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending applications be sure to list the key and job number.

When making application for a position include eight cents in stamps for forwarding application to the employer and for returning when possible.

A weekly bulletin of engineering positions open is available at a subscription rate of $3.50 per quarter or $12 per annum for members, $4.50 per quarter or $14 per annum for non-members, payable in advance.

In addition to the listings shown E.S.P.S. maintains a more complete file of general engineering positions and men available. Direct inquiries to nearest office.

Men Available

ENGINEER, B.S.E.E., 34. Plant engineering—five years'; specialized test equipment for production testing of major appliances—two years'. Location desired: Northwest. E-154.

ELECTRICAL ENGINEER, B.E.E., 33. Transmission, distribution, relay, metering and plant engineering. Ten years' experience in utility and industrial plants (chemical). Instrumentation and process control experience. Location desired: New England and Middle Atlantic States. E-155.

SALES MANAGER, B.S.E.E., 39. Three years' staff sales consultant responsible organizing sales departments, selection and training sales personnel, planning sales and area development programs; seven years' senior sales engineer and product sales supervisor. Location desired: U.S.A., will travel overseas. E-156.

ELECTRICAL ENGINEER DESIGN AND ESTIMATING, B.S.E.E., 58. 33 years' of experience in design, estimating, preparation of specifications, survey and reports for industrial buildings, power plants, substations, steel mills and associated industries. Location desired: Chicago. E-990-Chicago.

OPERATION AND/OR MAINTENANCE SUPERINTENDENT, B.S.E.E., Registered, 50. Twenty years' electrical and industrial experience in operation, maintenance and construction of substation and rotating equipment. Seven years' system planning and board study experience. Location desired: South or West. E-996-Chicago.

SYSTEM PROTECTION, SWITCHGEAR-UTILITY, MANUFACTURING: EIT, age 30. Good academic training with six years electric apprenticeship (varied manufacturing experience) followed by three years experience high power test on all types of switchgear. Five years manufacturing and utility fields on substation and hydro design. $650. Prefers San Francisco Bay Area. Home: Canada. S(M)-813.

DESIGN, OPERATION—ELECTRICAL, MECHANICAL: ME, age 52. Registered California EE and ME Licenses. Thirty years broad experience design, installation, maintenance and operation of utility systems in commercial and industrial buildings and areas including electric, water, heating, ventilation and air conditioning. $1000. Prefers Northern California. S(M)-795.

SALES, FIELD—INDUSTRIAL EQUIPMENT: EE, age 36. Fourteen years field engineering, select equipment, layout, coordinate information among sales, engineering and design, customer contact on industrial gas cleaning and air pollution control equipment for manufacturer; also inspect and test. Salary open. Prefers West Coast, Foreign. Home: Southern California. S(M)-1713.

ELECTRIC DESIGN—UTILITY: EE (Ireland), age 52. Thirty years design, field construction of substations, for utilities. Four months design industrial substations, switchgear, distribution for consultant. $6000. Prefers San Francisco Bay Area. Home: San Francisco. S(M)-580.

SALES, APPRAISAL, QUALITY CONTROL-HEAT, BLDGS, EQUIP: EE, age 44. Nine years adjuster, fire and marine claims of buildings and equipment for insurance organization. Two years draft, design, steel fabricating. Three and one-half years sales of heat transfer and purification equipment. Two and one-half years test, supervise assembly for automotive equipment manufacturer. $600. Prefer San Francisco or Los Angeles. Home: San Francisco. S(M)-546.

DESIGN, DEVELOPMENT—AIRCRAFT, MOTORS, GENERATORS: EE, age 38. Four years research design, develop, test, specifications on aircraft accessories, missiles. Four years design, development, motors, controls for power plants, textile drives, controls manufacturer. Salary open. Prefers California. Home: California. S(M)-470.

MAINTENANCE, DESIGN—OIL REFINERY: EE, age 34. Five years maintenance, design on oil refinery, manufacturing and shipping facilities. Two years field supervision, inspect equipment, installation, for AEC archt-engr. One year plant layout, inspect equipment installation for jet engine plants. Three years design, construction of automatic production machinery for manufacturer of electric switchgear and starters. $11,000. Any location. Home: Michigan. S(M)-464.

DESIGN—DISTRIBUTION, POWER PLANTS: EE (Holland), age 45. Two and one-half years design, construction substations, distribution systems for utility. Seventeen and one-half years supervise construction, design of power plants, transmission lines and distribution systems, work shops, warehouses, railroad for steel plants, oil refineries and oil fields and drilling companies.

Two years design, construction on shipbuilding. $700. Prefers San Francisco or any. Home: California. S(M)-398

RESEARCH—TRONICS: Dr Phys, Tronics, age 39. Two and one-half years research, develop, design, new products planning, commercial and military communications, tronics; for manufacturers. Nine years advisor, charge of marketing, manufacturing, on tronics for industrial firms. $25,000. Prefers West Coast. Home: Peninsula. S(M)-250

DESIGN, CONSTRUCTION SUPERINTENDENT—NUCLEAR POWER: EE, age 38. Eleven years charge planning, supervision of design, specifications, cost estimates, liaison on construction, field inspections on facilities, equipment structural, electric control systems for nuclear energy plants. $875. Prefers Western US, Foreign. Home: California. S(M)-1640

ADMIN, SALES—ELECTROMECHANICAL: AB Tronics, age 40. Two and one-half years administrative duties of engineering department of mining equipment manufacturer. Two years sales, design, installed accounting and control systems. Four years direct plan and schedule of production engineering division of tape recorder manufacturer. Two years instructor tronics. $10,000. Prefers West, East Coast. Home: California S(M)-287.

SALES—SWITCHGEAR, CONTROLS: Age 45. Three months plant estimator, develop prices from blueprints, negotiate with electrical contractors and distributors, work with design department for electrical switchgear and motor controls manufacturer. 2 years sales manager on switchgear. Ten years power sales to commercial and industrial accounts, for utility. Two years estimator and sales for electrical contractors. $600. Prefers San Francisco, Chicago. Home: California. S(M)-1051

SUPERINTENDENT—CONSTRUCTION: EE, age 44. California Electrical Engineer License. Eleven years self-employed building homes, apartments, schools, and light construction. Two and one-half years manager for home building and tract development. Three and one-half years research, develop, liaison with manufacturing in installation of prototypes of radar training devices for government. Five years estimator for gas, water and electrical construction, for utility. $12,000. Prefers San Francisco Bay Area. Home: Bay Area. S(M)-159

DESIGN, SUPERINTENDENT—ELECTRICAL CONSTRUCTION: EE, age 32. Six years experience design, layout, field on electric power, controls, instrumentation systems of oil refineries; for engineers—constructors. Seven months maintenance, trouble shooting, design, layout of control circuits and electric power systems for test of rocket engines. $12,000. Prefers Foreign, Pacific, Europe. Home: California. S(M)-1447

SUPERINTENDENT—ELECTRIC CONSTRUCTION: EE, age 53. Six years superintendent in charge of electrical construction of aluminum and chemical plants, military installations, power plants for constructors and engineers. Eight months self-employed on electric surveys and estimates for contractors. One year estimating on hospital. Three and one-half years supervising electric installations of hardwood board manufacturing plant. $800-1000 month. Prefers West, South, Foreign. Home: Mississippi. S(M)-1444

Positions Available

ASSOCIATE RESIDENT ENGINEER, 24-29, graduate electrical or mechanical, with experience in installation and connection of manufacturing equipment, or an industrial engineering degree with adequate courses in electrical and mechanical engineering courses in electrical and mechanical engineering. Should have at least two years experience in the field supervising installation of manufacturing or process equipment including responsibility for its connection with electrical and mechanical services. Duties

will include full responsibility for supervision of a smaller project in full, or assisting on a larger project. Some travel. Salary, to start, from $6730 a year depending upon experience. Location, upstate New York. W7830.

TRANSFORMER DESIGNER, electrical graduate, with experience in the design of pulse and military transformers. Salary open. Location, Maryland. W7845.

TEACHING PERSONNEL in electrical engineering, B.S. or M.S. degree in electrical engineering, to teach subjects such as electronics, instrumentation, servo mechanisms, electrical control systems, electric machines, electric circuits. Must have had considerable experience in industry or in teaching. Rank and salary dependent upon background. Location, Michigan. W7886.

SENIOR OR STAFF ENGINEER OR PHYSICIST, for micro-wave tube research, B.S., M.S. or Ph.D., to plan, supervise and conduct research in micro-wave tubes. Salary, $13,000-$17,000 a year. Location, New York, N. Y. W7914.

RESEARCH AND DEVELOPMENT ENGINEER, E.E. graduate, with at least five years' experience on electro-mechanical devices including servos, automatic controls and magnetic amplifiers. Salary, $8000-$10,000 a year. Location, southern Connecticut. W7934.

TECHNICAL EDITOR, under 30, electrical or mechanical degree, and some design experience. Must be able to write fluently and well, and should show evidence of such ability. Duties include the procurement, selection, writing and editing of articles and feature departments, for a national technical publication. Salary open. Location, Ohio. W7954.

DEVELOPMENT ENGINEERS. (a) Product Development Engineer, B.S. in electrical, chemical engineering, or chemistry, with three to eight years' experience in coated electrical insulation field to carry out analytical, research and development assignments, relatively broad in nature. Salary, $8000-$10,000 a year. (b) Machine Development Engineer, to 35, with degree in mechanical and/or electrical engineering, with at least five years' experience in manufacturing as project engineer, plant engineer or maintenance engineer in design and fabrication. Supervisory experience desirable. Salary, $8000-$10,000 a year. Company pays placement fees. Location, central New Jersey. W7957.

PRODUCT PLANNER, electrical or mechanical graduate, preferably with at least MBA degree in marketing and industrial management, with at least five years' experience in design, new product development and application engineering of military defense products covering missile control systems and electronic components. Considerable travel. Salary open. Location, Midwest. W7962.

DESIGN ENGINEER, Electronic Test Equipment, graduate electrical, with three to five years' experience in the design and manufacture of electronic and electrical test equipment and/or related experience in the data processing field. Salary open. Location, Connecticut. W7965.

PRODUCT DESIGN AND DEVELOPMENT ENGINEERS, mechanical or electrical graduates, with experience in the design and development of consumer electrical appliances or allied fields. Good working knowledge of materials, Underwriter's requirements, heating devices, temperature controls, manufacturing methods and costs. Creativity and real interest in product development work. Salaries, to $10,000 a year. Location, upstate New York. W7968.

ELECTRICAL ENGINEERS with experience on magnetic amplifiers, servos and controls. (a) Senior Design Engineer, electrical, with at least ten years' experience. Salary, $10,000-$12,000 a year. (b) Designer with five years' experience. Salary, $8000-$10,000 a year. (c) Junior Designer. Salary, $6000-$7500 a year. (d) Field Service Engineer with industrial electronic equipment installation and servicing experience. Salary open. Location, Connecticut. W7979.

(Continued on page 78A)

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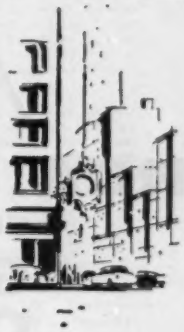
NEW opportunities at Motorola in Chicago

give yourself and your family all the big city advantages at a relaxed midwest pace, while you ADVANCE YOUR CAREER



Outstanding career opportunities are waiting at the many Motorola research and development laboratories in the Chicago area. This is your opportunity to advance your career with a swiftly expanding company, working in the most modern and well instrumented laboratories . . . with liberal employee benefits, including an attractive profit sharing plan and association with men of the highest technical competence.

You'll like living in one of the beautiful suburbs of the playground of the midwest, where there are endless social, cultural, and educational activities to choose from the year-round. Exciting life or quiet life—Chicago offers either.

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- Radar transmitters and receivers
- Radar circuit design
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- IF strip design
- Device using kylstron, traveling wave tube and backward wave oscillator
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• VHF & UHF Receiver • Transmitter design & development • Power supply • Systems Engineering • Selective Signaling • Transistor Applications • Crystal Engineering • Sales Engineers

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• Design of VHF & UHF FM Communications in portable or subminiature development.

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Inquiries are invited for key openings at RCA's new, ultra-modern Semiconductor and Materials headquarters in suburban Somerville, New Jersey (just 35 miles from New York City), from individuals with degrees in . . .

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Dept. SE-58

EQUAL OPPORTUNITY For All Qualified Applicants

RADIO CORPORATION OF AMERICA
SEMICONDUCTOR AND MATERIALS DIVISION, SOMERVILLE, NEW JERSEY

Personnel Service, Inc.

(Continued from page 77A)

ENGINEERS. (a) Assistant Chief Engineer, Navigation, B.S. in E.E., with M.S. desirable, with at least ten years' experience in the design and development of navigation and guidance equipment with four or more years' at the project administration level. Specific knowledge of doppler, inertial and star tracking systems desirable. Strong background in proposals. Will be responsible for administration and operation of navigational laboratory. Salary, to $19,000 a year. (c) Quality Control Supervisor, B.S. in M.E. or E.E., with broad experience in quality control, preferably in electronic manufacture; experience in setting up quality control processes desirable. Experience with IBM systems helpful. Good communication ability. Will be responsible for reporting, data analysis, quality control procedures, quality control manuals and office supervision. Salary, to $10,500 a year. All applicants must be U.S. citizens. Company pays placement fees. Location, New York State. W7990.

TECHNICAL PUBLICITY electrical engineer or equivalent experience, for a public relations department. Proven skill in preparing feature articles, case history reports, product publicity in electrical fields. Good salary, profit sharing, fringe benefits. Excellent future. Location, eastern Pennsylvania. W7994.

SENIOR ELECTRICAL ENGINEER, graduate with about fifteen years' experience in the mining and milling field, for the design and layout of power distribution systems, for supplying power to crushers, rod mills, ball mills, conveying systems and allied equipment. Plant lighting system also included. Salary, to $14,000 a year. Location, New York, N. Y. W8001(a).

ELECTRICAL GRADUATE, Project Engineer, with at least five years' supervisory experience on industrial electronic controls and equipment in special machinery fields. Salary, to $10,000 a year. Location, New Jersey Metropolitan area. W8004(a).

ENGINEERS, mechanical and electrical graduates, in the area of plant and facilities design, young, for the design of new and renovated buildings including heating, plumbing, process piping, air conditioning, ventilating, wiring, etc. One to five years' similar design experience desired. Salary, $7000-$10,000 a year. Location, Massachusetts. W8012.

PROJECT ENGINEER, graduate electrical engineer or electronics, 30-40; five or more years' experience in instrumentation and electronic equipment as applied to chemical, paper and plastics field. Duties: At project engineer level to design and develop electronic equipment, will contact and consult with manufacturers of packaging machinery and equipment, to evaluate performance of new plastic films on equipment. Should have good personality. Travel 15% for a manufacturer of plastic film. Salary, to $10,000 a year. Employer will pay placement fee. Location, Chicago. C7712-A.

APPLICATION ENGINEER—TRONIC ANALOG SYSTEM: Degree, Minimum three years' experience in design of plans, specifications and estimates for development, modification and construction of tronic analog systems to solve engineering and scientific problems, related to development, conservation, control and utilization of water resources. Wide knowledge of the theory and application of current analog equipment and ability to establish and dispense information relating to such programs. For division of the State. $675-$825. Sacramento Valley. S(P)-4702

PROJECT PLANNER, TRONIC—ELECTRO-MECHANICAL: Prefer EE or ME with MS Bus, age 28-40. Recent high level experience in production planning relating to studies, reports and recommendation to management of market potential, plant capacity, technical level on items in production or for new production. Relates to inertial systems, computors, navigational, communications (gyros, accelerators, systems, sub-system). For military, non-military or automotive. Will work with advance system designers, sales and management to determine potential. $10,000-$15,000. Wisconsin. S(P)-4701

COMMUNICATION ENGINEERS—DEVELOPMENT; Four to six years' experience circuit and equipment development transistorizing commercial products. San Francisco. S(P)-4684-R

SALES ENGINEER—ELECTRIC TRONIC EQUIPMENT: EE, to 40. Well qualified by experience on electric and aircraft engineering to promote sale of potentiometers, aircraft solenoids and valves and air data instrumentation. Should have capacity for assisting in direction of other salesmen. About $800 month plus expenses and car allowances. Northern California, San Francisco Headquarters. S(P)-4613

TECHNICAL WRITER—TRONIC, MECHANICAL DEVICES: EE pref, to 45. Responsible for all instruction manuals and technical reports. Ability to understand and describe electronic and mechanical devices; capable of clear writing and clean organization. $650-$700, depending on experience. US citizenship required. San Francisco Peninsula. S(P)-4584

FIELD SALES ENGINEER—INSTRUMENTATION: EE or Phys, Desire engineering training and some sales experience. Will consider strong interest in selling instrumentation. For manufacturer. Salary open. Northwest. S(P)-4688

DESIGN, DEVELOPMENT ENGINEER — TRONICS, INSTRUMENTS: Recent graduate or two to five years' experience. Familiar with circuit design for bridge-type measuring, null detectors, power supplies, etc. For manufacturer. Salary open. Northwest. S(P)-4688(b)

DESIGNER LIGHT, POWER: EE, prefer with California Registration, under 45. Able to prepare plans and specifications, handle outside contacts with clients and contractors and inside office work. For consultant. San Francisco East Bay. S(P)-4687

ECONOMIC STUDIES—TRONIC: EE, with tronic major, young. Junior, recent graduate with some training, or senior with minimum five years' production planning, product design or industrial marketing. Will contact users and manufacturers to investigate and determine products, specifications and market. This is economic research type of activity and strong preference will be given to above experience plus busines administration. Current product emphasis is on computers and tronic equipment. For research institute. San Francisco Peninsula. S(P)-4684

QUALITY CONTROL MANAGER—MISSILES SYSTEMS: Engineering degree; minimum eight to fourteen years' quality control with six to eight years' recent supervisory experience. Able to direct 600 employees engaged in inspection, test and quality control operation relating to production, research and development and large defense contract (missiles systems and some radar). U.S. citizens, security clearance required. $12,-$16,000. Western Mountain States. S(P)-4679

PLANT ENGINEER—LIGHT MANUFACTURE: EE or ME, age 30-45. Minimum seven years' recent plant engineering experience as assistant or plant engineer in large organization engaged in light manufacturing or tronic component manufacturing. West Coast men only. About $1000. San Francisco Peninsula. S(P)-4677

DESIGNER DIGITAL DATA HANDLING SYSTEMS: EE, minimum five years' design of digital data handling systems, including working knowledge of milimicrosecond pulse and solid state circuit techniques. To design systems. $10-$12,000 year plus profit sharing bonuses. San Francisco East Bay. Employer pays placement fee. S(P)-4675-R

SUPERVISING ENGINEER—MECHANICAL PLANT: EE or ME, California License required. Will provide plant engineering type support to municipal activity (contact with clients, tenants, architects, engineers, contractors) in office building, meeting halls, public buildings, service organizations and shops. Should know power and light, air conditioning and heating and subsequently pass civil service examination. For municipality. San Francisco East Bay. $725. S(P)-4657

(Continued on page 80A)

New Problems in Advanced

RESEARCH & DEVELOPMENT

Challenge Engineers at

GENERAL DYNAMICS
Electric Boat Division

Pioneer in design and development of nuclear powered submarines, Electric Boat Division is embarked upon a broad program of expansion and diversification in advanced technological areas.

One project now underway is a complex simulator for training Polaris weapon system crews in submarine control, navigation and missile firing. This trainer, housed in its own building, uses a DC analog computer to provide realistic response to trainee actions and will permit practice of normal operations as well as emergency drills which may be too dangerous to perform in operating submarines.

Other stimulating work areas include large control systems (140-foot precise radio telescope, world's largest wind tunnel, submarine systems); training equipment (simulators and trainers for missiles, submarines and other weapons systems); advanced submarine development (integrated control systems for sonar, navigation, missile launching and weapons guidance).

Immediate Opportunities in:

SYSTEMS

EE, ME or Physics degree required. Responsible for conceptual engineering and systems analysis of large complex devices employing a combination of electrical, electronic, electromechanical, hydraulic and pneumatic systems. Should be familiar with servomechanisms theory, experienced in use of analog or digital computers as a design tool, and have a good grasp of mathematics. Will work on proposal preparations, feasibility studies and execution of hardware contracts.

CIRCUITS

Responsible for conceptual and production engineering of electronic equipment. Familiar with servomechanisms and analog computer theory. Experienced in use of semiconductors, magnetic amplifiers and vacuum tube circuit elements; good grasp of mathematics; EE or Physics degree.

COMPUTERS

Responsible for conceptual engineering and programming of special purpose digital and analog computers. Should be familiar with system engineering, experienced in programming and check systems for both analog and digital computers, with good grasp of simulation techniques. Requires EE, Physics or Mathematics degree.

OPERATIONS RESEARCH

PhD in physical sciences required. To be responsible for operations research studies of submarine and anti-submarine weapons systems.

SERVOMECHANISMS

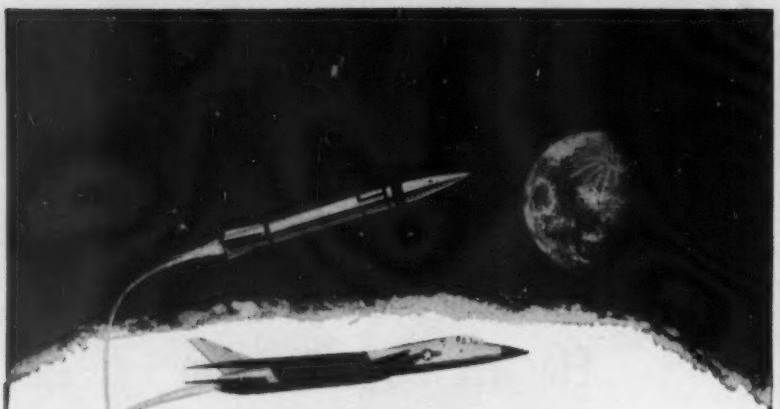
For engineering design of servomechanisms in both the instrument and multiple horsepower class. Will interpret performance specifications and be responsible for design of a system in accordance with the specifications, including stability studies, and the calculation of other performance criteria.

Electric Boat Division is located on the beautiful Connecticut shore near New London. Situated half way between Boston and New York City, it affords gracious New England living and year round recreation for you and your family.

To arrange convenient appointment, write in confidence to James P. O'Brien, Technical Employment Supervisor.

GENERAL DYNAMICS
Electric Boat Division

GROTON CONNECTICUT



ADVANCED DESIGN

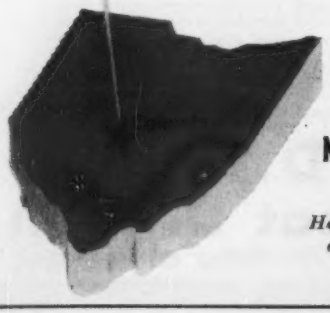
Several positions are available in the Advanced Design Section for senior engineers and scientists. Our Advanced Design Section is divided into two groups: Preliminary Design and Military Operations Analysis.

Preliminary Design engineers are responsible for both aircraft and missile configuration, performance, structures, propulsion, electronics, and support equipment. Intensive experience in any of these areas is a prerequisite.

The Military Operations Analysis group is investigating requirements for advanced Logistic, Defense, Attack and Reconnaissance Systems. This group is responsible for being familiar with the state of the art in all military weapons areas, using this information to optimize weapon proposals.

Current studies in Advanced Design are exploring new concepts in underseas warfare, land combat, and aerial warfare, including VTOL-STOL, missiles of all types, ground handling and support equipment, and other still confidential studies.

Engineers, Mathematicians and Physicists are invited to write for more information to Engineering Personnel, Box EE-498, North American Aviation, Inc., Columbus, Ohio.



THE COLUMBUS DIVISION OF NORTH AMERICAN AVIATION, INC.

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Personnel Service, Inc.

(Continued from page 79A)

DESIGNER—ANALOG COMPUTERS: EE, minimum five years' design of analog computer systems or simulators. Be informed about mechanical, mechanisms, transistorizing, tronics and electric needs. Will participate in general program project level, for manufacturer. $10-$12,000 year, plus profit sharing bonuses. Employer will pay placement fee. San Francisco East Bay. S(P)-4653-R

SALES ENGINEER—INSTRUMENTATION: EE or ME. Two years' industrial sales desirable. Knowledge and aptitude for application engineering and sales of recording tronic instruments for national manufacturer. Work in Northern California from San Francisco Peninsula headquarters contacting industrials, labs, o.e.m.'s, missiles and tronic clients. U.S. citizen. Employer pays placement fee and relocation costs and expenses. $9000 plus company car. S(P)-4653

DESIGNER—POWER SUPPLY SYSTEMS: EE, plus Tronics. Well qualified in static power systems, including circuit design experience, some packaging, transistorizing of ground support regulated power supply equipment. For manufacturer. $12,000. Southern California. S(P)-4646(a)

ASSISTANT DESIGNER—OSCILLOSCOPE: EE, plus Tronics, young. Recent graduate to two years' working experience, to engage circuit design and packaging of large oscilloscopes instrumentation, including swept frequency generators. For manufacturer. U. S. citizen only. Relocation and placement fee paid. To $9500. Southern California. S(P)-4646(b).

SALES ENGINEER—TRONIC INSTRUMENTATION: EE, to 40. Experienced selling and providing application assistance to clients for use of precision tronic control devices (deliver reading, indicating or control type). For user or o.e.m. or application such as oven controls, furnace controls, with opportunity for greater compensation. San Francisco Bay Area men only. $600-$800. S(P)-4582.

ASSISTANT PROFESSOR — ELECTRICAL: Minimum MS EE, PhD preferred, to teach undergraduate courses. Former teaching and professional experience desirable, although not necessary. U. S. citizen desired. Salary commensurate with rank and experience. Pacific Island. S(P)-4644-R.

DESIGNER—ELECTRIC CONTROL SYSTEMS: EE, with advanced control engineering, to 45. Recent and solid experience at high level in all phases of complex industrial motor control related to use, application and operation of special and varied components such as magnetic amplifiers, semi-conductors, computer elements for operation and automation of machine tools, conveyors, crane, missile towers and instrumentation. Unusual opportunity in San Francisco Area with small well-financed corporation with outstanding reputation in design and manufacturer of diversified control systems. $12,000-$20,000. Apply by letter. S(P)-4638-R.

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Positions Open

INSTRUCTORS AND RESEARCH ENGINEERS to work for D.Sc at University of New Mexico. Large Graduate program assures variety of available courses. Chairman, E.E. Department, University of New Mexico, Albuquerque, New Mexico.

DEPARTMENT HEAD ELECTRICAL ENGINEERING. Immediate appointment available to the vacant chair in Electrical Engineering in rapidly growing Engineering faculty. Academic experience required. Salary up to $14,500, depending on qualifications. Teaching fellowships available for graduate students and research assistants. Medical, hospital and pension plans in effect; group insurance being arranged. Send applications to F. A. DeMarco, Principal, Essex College, Windsor, Ontario, Canada.

RELAY TEST ENGINEER. Excellent opportunity in relay test section of Massachusetts Utility. Good knowledge of electronics a necessity, E.E. degree helpful. Salary commensurate with experience. Write resume of experience, education, personal data, and salary requirements. All held in strict confidence. Box 36.

ASSISTANT OR ASSOCIATE PROFESSOR for Electrical Engineering Department. MS or PhD degree required. Opening in electronics. Salary commensurate with experience and education. Position available September 1959. Write Head, Electrical Engineering Department, South Dakota School of Mines and Technology, Rapid City, South Dakota.

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INTERESTING POSITION WITH OPPORTUNITY for young Electrical Engineer in Minneapolis headquarters service department of manufacturer of larger industrial motors and controls. Excellent future for right man. Box 50.

RELAY ENGINEER. Recent graduate engineer preferably with some experience in electric utility, interested in protective relaying and automatic control of generating and transmission stations; capable of assuming responsibility on in-service checks on major electrical settings. Ohio Power Company, Room 555, Canton, Ohio.

TEACHING POSITION. Excellent teaching opportunity will be available beginning February or September 1960. Advanced degree required. Attractive full-year contract available. Salary range for 9 months is 5,000 to 7,000 dollars.

(Continued on page 84A)

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RCA COMMUNICATIONS AND COMPUTER PROJECTS

Imagination, applied by RCA engineers to the most challenging problems in communications and computer science, has created the airborne and ground equipment for the TDM Data-Link Systems, world-wide communications networks, air and sea navigation systems, palm size television and the world's most advanced electronic data processing system.

Creative top-level engineers are needed now to work on advanced assignments in digital communications, data processing, RF communications, microwave, telemetering, tropospheric and ionospheric scatter, and visual displays. Openings include positions for engineering management, development and design, systems and project engineers.

Qualified engineers are invited to discuss their interest in our current programs. To arrange an interview with engineering management please send resume to: Mr. C. B. Gordon, Box Z-19L, Professional Placement, Bldg. 10-1, RCA, Camden, N. J.

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Challenging positions open for high caliber Electrical Engineers with some experience to work in interesting research and development programs in instrumentation and circuitry.

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Excellent employee benefits, including liberal vacation policy and tuition-free graduate study. Please send resume to:

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- **To be key member of small integrated group.**
- **Interesting, challenging opportunity in Research and Development problems of an Industrial nature.**

Duties include preliminary analysis, design and development of experimental equipment and the design and testing of prototypes. Working knowledge of automatic controls for industrial machinery, high voltage rectifier equipment or high voltage gaseous discharges desirable. Some design and development experience required.

Send resume to H. W. Buswell, Employment Supervisor, Koppers Company, Inc., Metal Products Division, P.O. Box 298, Baltimore 3, Maryland.

ELECTRICAL ENGINEERS

1. One to two years' experience with B.S. degree.
2. Senior engineers with eight to ten years' experience in television circuitry, computer circuitry and transistor circuitry with M.S. degree in electrical engineering or equivalent.

This is a new project in an old established company. Advancement prospects and company policies are good.

A. B. DICK COMPANY
5700 W. TOUHY AVENUE
NILES, ILLINOIS

Electrical Engineers with 1 to 15 years experience in Application, Control, Control Systems or Development Engineering. Location: Cleveland, Ohio Division

Circuit Breaker Design Engineers—Experienced.

Send resume to Personnel Director, Square D Company, EC&M Division, 4500 Lee Road, Cleveland 28, Ohio.

INSTRUMENT APPLICATION ENGINEER

Large industrial instrument manufacturer has openings for young graduate engineers in expanding Application Engineering Department. Require several years' experience with electrical or electronic equipment, and interest in assisting customers with their instrument problems. Some traveling. Plant located in suburban New England Town away from big city confusion. Drive to work in ten minutes. Send resume to Box 52, Electrical Engineering, 33 West 39th St., New York 18, N. Y.

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Address all resumes, stating salary requirements to
MR. JOHN E. BAKER

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AC MOTOR DESIGNER
ATOMIC EQUIPMENT DEPT.
First in Atomic Power

CHESWICK, PENNSYLVANIA

E.E. degree. Experience necessary in AC induction motor design. Knowledge of materials and fabrication methods desirable. Specific responsibilities will be in the development and design of motors used primarily in pumping application. Must keep informed as to the latest developments & materials and design techniques. Relocation expenses paid to qualified applicant. Many liberal employe benefits.

BIBLIOGRAPHY ON ELECTRONIC POWER CONVERTERS

A compilation of considerable reference data on power rectifiers and inverters, published in chronological sequence beginning with 1903. Items are arranged alphabetically by the author's surname, and are further classified according to text matter. Prepared by the Subcommittee on Papers and Speakers of the AIEE Electronic Power Converter Committee.

Priced at $1.00 ($0.50 to AIEE members), publication S-35 (February 1950) is available from the Order Department, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, 33 West 39th Street, New York 18, N. Y.

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   A brief statement of the heritage and the responsibilities of the profession.

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Positions are available at these Western Electric Locations: Winston-Salem, Greensboro and Burlington, North Carolina Laureldale, Pennsylvania and Whippany, New Jersey

For a personal interview in your area or at one of the above locations, address your resume to: Mr. T. R. Lannon Engineering Employment Manager, Dept. 924B.

Western Electric

MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

Lexington Road, Winston-Salem, North Carolina

Classified Advertising

(Continued from page 81A)

Location is in the Midwest at a medium-size private university. Send complete resume to Box 51.

EXPANDING ELECTRICAL DEPARTMENT. Need two additional staff members with backgrounds in physical electronics, solid state, or microwaves. Doctor's degree preferred. Rank of assistant professor or associate professor, depending on qualifications. Salary $6000 to $9000 for session, ten months nominal, nine months actual. Start February or September, 1960. Fully accredited electrical engineering department in medium-sized University (700 undergraduate students in Engineering) located in a very pleasant uncrowded city of 350,000. Address resume or inquiries directly to Dean Otto Zmeskal, College of Engineering, University of Toledo, Toledo 6, Ohio.

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DESIRE TEACHING AND RESEARCH APPOINTMENT with Electrical Engineering department. Ph.D. Industrial, supervisory, and university teaching experience. Available Fall 1959. Box 53.

A.I.E.E. TRANSACTION wanted to buy for cash back volumes and sets, also other scientific and technical Journals—E. E. ASHLEY, 27 East 21st Street, New York 10, New York.

FOR SALE: One Allis Chalmers Transformer, 8 years old, 1000 KVA, Class OA; also one Switch Gear, 5000 Volts maximum capacity, dual intake lines, single outlet complete. Contact: Geilich Tanning Company, Taunton, Massachusetts.

Safety in Industrial Power Distribution Systems (A SYMPOSIUM)

The five conference papers on safety prepared in this publication, were presented at the AIEE Winter General Meeting, New York, N. Y., February 1-6, 1958.

The 24-page booklet, S-108, December 1958, sponsored by the AIEE Industrial and Commercial Power Systems Committee, may be ordered at the cost of $1.00 from the Order Department,

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American Brass Co. 60A
AMP, Inc. 33A
Anaconda Wire & Cable Co. 8A-9A
Armco Steel Corp. 63A
Armour Research Foundation of Illinois Institute of Technology 82A, 86A
Arnold Engineering Co. 67A
Automatic Switch Co. 19A

Bell Telephone Laboratories 40A
Biddle Co., James G. 38A
Bussmann Manufacturing Co. 14A-15A

Chase-Shawmut Co. 61A
Christie Electric Corp. 36A
Clark Controller Co. 2A
Classified Advertising 81A, 84A
Collyer Insulated Wire Co. 65A
Continental-Diamond Fibre Corp., A Subsidiary of The Budd Co., Inc. 69A

Dick Co., A. B. 82A
Douglas Aircraft Co. 58A-59A

Enjay Co. 25A
Erico Products Inc. 31A

Federal Pacific Electric Co. 44A

Gai-Tronics, Inc. 28A
General Dynamics-Electric Boat Division 79A
General Electric Co. ..... 4th cover, 20A-21A, 51A-54A, 62A, 64A
General Radio Co. ..... 3rd cover
General Telephone Laboratories 30A

Hughes Aircraft Co. 66A
Hughes Research & Development Laboratories 74A-75A

International Business Machines Corp. 46A
International Rectifier Corp. 16A
I-T-E Circuit Breaker Co. 6A-7A

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Koppers Co. 82A
Kuhlman Electric Co. ..... 2nd cover

Marcus Transformer Co. 64A
Motorola, Inc. 77A

National Carbon Co., Division of Union Carbide Corp. 17A
National Electric Coil Co. 43A
Natvar Corp. 27A
Nelson Electric Manufacturing Co. 48A
North American Aviation, Inc., Columbus Division 80A

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Ohmite Manufacturing Co. 39A
Oldsmobile Division, General Motors Corp. 73A

Paranite Wire & Cable Co. 47A
Perkin Engineering Corp. 4A-5A
Personnel Service, Inc. 76A, 77A, 78A, 79A, 80A
Professional Engineering Directory 50A

Radio Corporation of America 56A, 78A, 81A
Radio Frequency Laboratories, Inc. 26A
Raytheon Manufacturing Co. 68A

Sandia Corp. 45A
Sarkes Tarzian, Inc. 24A
Sola Electric Co. 88A
Sorensen & Co. 22A
Sorgel Electric Co. 32A
Southern States Equipment Co. 12A-13A
Spaulding Fibre Co. 49A
Speedry Products Inc. 56A
Square D Co. 29A, 82A
Superior Electric Co. 71A-72A

Tektronix, Inc. 70A

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(Pounds per 1000 Feet)

Conductor Size AWG or Mcm	Copper & Copper Alloy Conductors: URC Type Double Braid	URC Type Triple Braid	Neoprene Type	Polyethylene Type	Aluminum Conductors: Neoprene Type	Polyethylene Type
Stranded						
2	246	270	248	**230**	105	**87.4**
4	155	170	163	**143**	73.3	**53.3**
6	103	115	108	**91.5**	51.5	**35.0**
Solid						
2	239	260	232	**219**	92.2	**79.2**
4	151	164	152	**136**	64.0	**48.0**
6	100	112	101	**87**	45.7	**31.7**

Sources: American Standards Association Specifications

This table shows

POLYETHYLENE covered line wire weighs less

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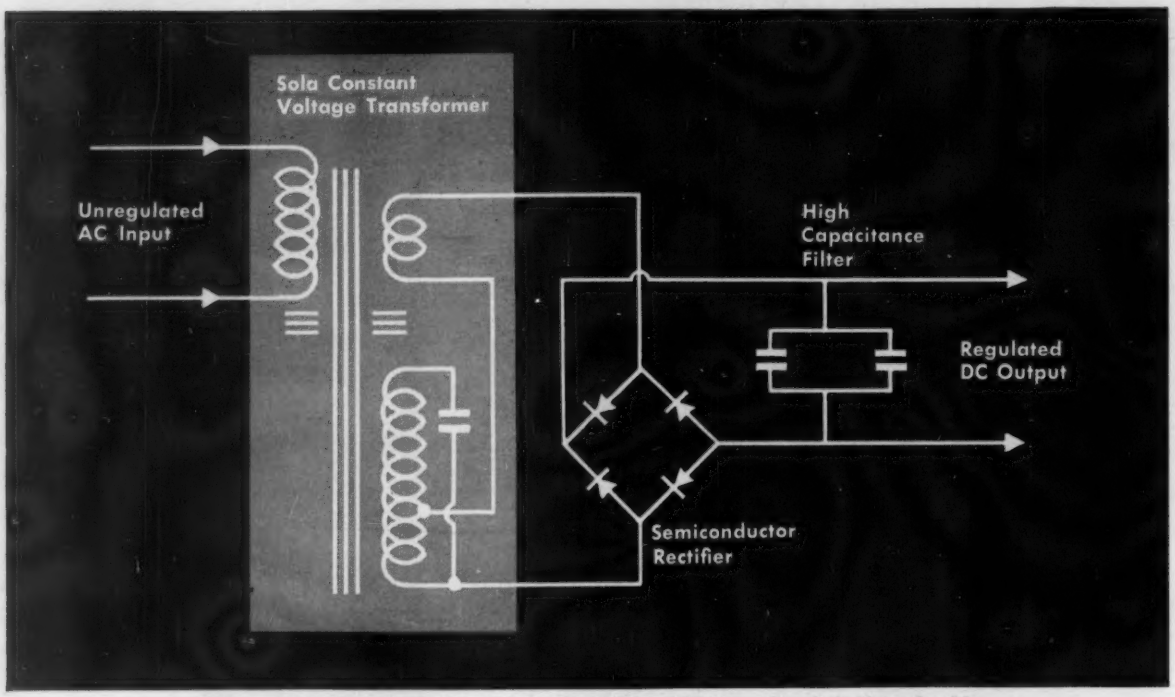

Inherently simple design of the Sola Constant Voltage DC Power Supply is shown by this general schematic diagram. Its basic simplicity of design and its reliable components make this regulated power supply rugged and dependable, both electrically and mechanically.

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For complete data write for Bulletin 5K-CV-235

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★ The ideal instrument for producing timing markers at intervals from 0.1 μsec to 100 μsec for calibrating oscilloscope sweeps, receivers, transmitters, and other test equipment.

★ Usable beat notes for measurements can be produced with 50-mv input signal.

★ Touch-button frequency deviator can be used to introduce a momentary frequency decrease for establishing "sense" in indications near zero beat.

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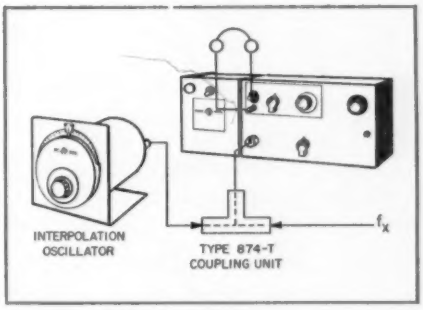

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